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EXPERIMENTS WITH THE LANGLEY AERODROME.*

By S. P. LANGLEY.

THE experiments undertaken by the Smithsonian Institution upon an aerodrome, or flying machine, capable of carrying a man, have been suspended from lack of funds to repair defects in the launching apparatus without the machine ever having been in the air at all. As these experiments have been popularly, and of late repeatedly, represented as having failed on the contrary because the aerodrome could not sustain itself in the air, I have decided to give this brief though late account, which may be accepted as the first authoritative statement of them.

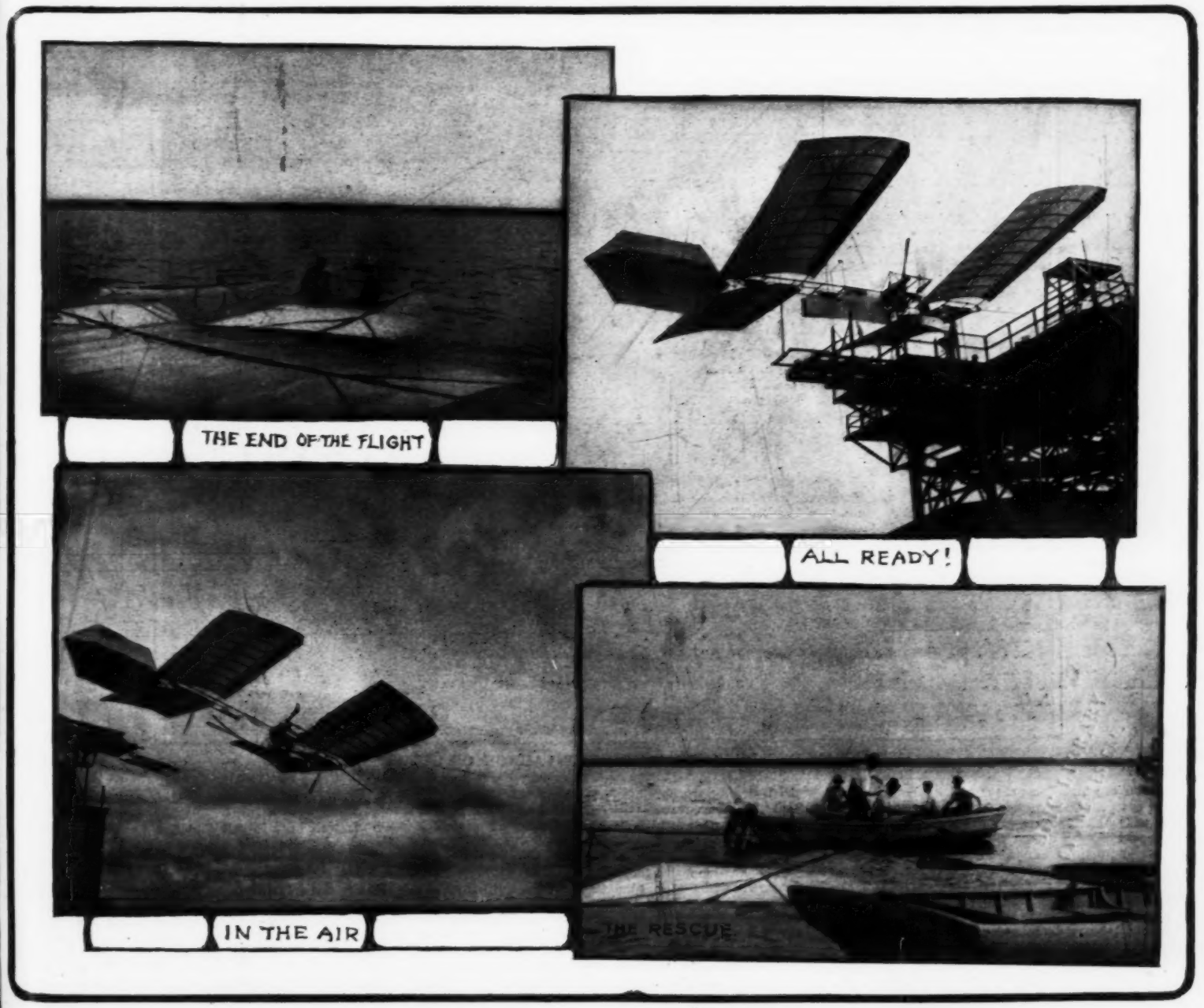
It will be remembered that in 1896 wholly successful flights of between one-half and one mile by large steam-driven models, unsupported except by the mechanical effects of steam engines, had been made by me. In all these the machine was first launched into the air from "ways," somewhat as a ship is launched into the water, the machine resting on a car that ran forward on these ways, which fell down at the extremity of the car's motion, releasing the aerodrome for its free flight. I mention these details because they are essential to an understanding of what follows, and partly because their success led me to undertake the experiments on the much larger scale I now describe.

In the early part of 1898 a board, composed of officers of the army and navy, was appointed to investigate these past experiments with a view to determining just what had been accomplished and what the possibilities were of developing a large-size man-carrying machine for war purposes. The report of this board being favorable, the Board of Ordnance and Fortification of the War Department decided to take up the matter, and I having agreed to give without compensation what time I could spare from official duties, the board allotted $50,000 for the development, construction, and test of a large aerodrome, half of which sum was to be available immediately and the remainder when required. The whole matter had previously been laid before the Board of Regents of the Smithsonian Institution, who had authorized me to take up the work and to use in connection with it such facilities of the Institution as were available.

Before consenting to undertake the construction of this large machine, I had fully appreciated that owing to theoretical considerations, into which I do not enter, it would need to be relatively lighter than the smaller one; and later it was so constructed, each foot of sustaining surface in the large machine carrying nearly the same weight as each foot in the model. The difficulties subsequently experienced with the larger machine were, then, due not to this cause, but to practical obstacles connected with the launching, and the like.

I had also fully appreciated the fact that one of the chief difficulties in its construction would lie in the procuring of a suitable engine of sufficient power and, at the same time, one which was light enough. (The models had been driven by steam engines whose water supply weighed too much for very long flights.) The construction of the steam engine is well understood, but now it would become necessary to replace this by gas engines, which for this purpose involve novel difficulties. I resolved not to attempt the task of constructing the engine myself, and had accordingly entered into negotiations with the best engine builders in this country, and after long delay had finally secured a contract with a builder who, of all persons engaged in such work, seemed most likely to achieve success. It was only after this contract for the engine had been signed that I felt willing to formally undertake the work of building the aerodrome.

The contract with the engine builder called for an engine developing 12 brake horse-power, and weighing not more than 100 pounds, including cooling water and



THE FAILURE OF LANGLEY'S AERODROME.

* Reprint from the Smithsonian Report for 1904.

all other accessories, and with the proviso that a second engine, exactly like this first one, would be furnished on the same terms. The first engine was to be delivered before the close of February, 1899, and the frame of the aerodrome with sustaining surfaces, propellers, shafting, rudders, etc., was immediately planned, and now that the engine was believed to be secured, their actual construction was pushed with the utmost speed. The previous experiments with steam-driven models, which had been so successful, had been conducted over the water, using a small house-boat having a cabin for storing the machine, appliances, and tools, on top of which was mounted a track and car for use in launching. As full success in launching these working models had been achieved after several years spent in devising, testing, and improving this plan, I decided to follow the same method with the large machine, and accordingly designed and had built a house-boat in which the machine could not only be stored, but which would also furnish space for workshops, and on the top of which was mounted a turntable and track for use in launching from whatever direction the wind might come.

Everything connected with the work was expedited as much as possible with the expectation of being able to have the first trial flight before the close of 1899, and time and money had been spent on the aerodrome, which was ready, except for its engine, when the time for the delivery of this arrived. But now the builder proved unable to complete his contract, and, after months of delay, it was necessary to decrease the force at work on the machine proper and its launching appliances until some assurance could be had of the final success of the engine. During the spring and summer of 1899, while these delays were being experienced in procuring suitable engines, former experiments on superposed wing surfaces were continued, time was found for overhauling the two steam-driven models which had been used in 1896, and the small house-boat was rebuilt so that further tests of these small machines might be made in order to study the effect of various changes in the balancing and the steering, equilibrium-preserving, and sustaining appliances, and the months of June, July, and a portion of August were spent in actual tests of these machines in free flight.

A new launching apparatus following the general plan of the former overhead one, but with the track underneath it, was built for the models, and it was used most successfully in these experiments, more than a dozen flights in succession being made with it, while in every case it worked without delay or accident. As soon as these tests with the models on this underneath launching apparatus were completed, that for the large machine was built as an exact duplicate, except for the enlargement, and with some natural confidence that what had worked so perfectly on a small scale would work fairly on a large one.

It was recognized from the very beginning that it would be desirable in a large machine to use "superposed" sustaining surfaces (that is, with one wing above another) on account of their superiority so far as the relation of strength to weight is concerned, and from their independence of guy wiring; and two sets of superposed sustaining surfaces of different patterns were built and experimented with in the early tests. These surfaces proved, on the whole, inferior in lifting power, though among compensating advantages are the strength of a "bridge" construction which dispenses with guy wires coming up from below, which, in fact, later were the cause of disaster in the launching.

It was finally decided to follow what experiment had shown to be successful, and to construct the sustaining surfaces for the large machine after the "single-tier" plan. This proved to be no easy task, since in the construction of the surfaces for the small machines the main and cross ribs of the framework had been made solid, and, after steaming, bent and dried to the proper curvature, while it was obvious that this plan could not be followed in the large surfaces on account of the necessity, already alluded to, of making them relatively lighter than the small ones, which were already very light. After the most painstaking construction, and tests of various sizes and thicknesses of hollow square, hollow round, I-beam, channel, and many other types of ribs, I finally devised a type which consisted of a hollow box form, having its sides of tapering thickness, with the thickest part at the point midway between contiguous sides and with small partitions placed inside every few inches in somewhat the same way that nature places them in the bamboo. These various parts of the rib (corresponding to the quill in a wing) were then glued and clamped together, and after drying were reduced to the proper dimensions and the ribs covered with several coats of a special marine varnish, which it had been found protected the glued joints from softening, even when they were immersed in water for twenty-four hours.

Comparative measurements were made between these large cross ribs, 11 feet long, and a large quill from the wing of a harpy eagle, which is probably one of the greatest wonders that nature has produced in the way of strength for weight. These measurements showed that the large, 11-foot ribs ("quills") for the sustaining surfaces of the large machine were equally as strong, weight for weight, as the quill of the eagle; but much time was consumed in various constructions and tests before such a result was finally obtained.

During this time a model of the large machine, one-fourth of its linear dimensions, was constructed, and a second contract was made for an engine for it. The delay with the large engine was repeated with the small one, and in the spring of 1900 it was found that both contract engines were failures for the purpose for which they were intended, as neither one developed half of the power required for the allotted weight.

I accordingly again searched all over this country, and, finally, accompanied by an engineer (Mr. Manly), whose services I had engaged, went to Europe, and there personally visited large builders of engines for automobiles, and attempted to get them to undertake the construction of such an engine as was required. This search, however, was fruitless, as all of the foreign builders, as well as those of this country, believed it impossible to construct an engine of the necessary power and as light as I required (less than 10 pounds to the horse-power without fuel or water). I was therefore forced to return to this country and to consent most reluctantly, even at this late date, to have the work of constructing suitable engines undertaken in the shops of the Smithsonian Institution, since, as I have explained, the aerodrome frame and wings were already constructed. This work upon the engines began here in August, 1900, in the immediate care of Mr. Manly. These engines were to be of nearly double the power first estimated and of little more weight, but this increased power and the strain caused by it demanded a renewal of the frame as first built, in a stronger and consequently in a heavier form, and the following sixteen months were spent in such a reconstruction simultaneously with the work on the engines.

The flying weight of the machine complete, with that of the aeronaut, was 830 pounds; its sustaining surface, 1,040 square feet. It therefore was provided with slightly greater sustaining surface and materially greater relative horse-power than the model subsequently described which flew successfully. The brake horse-power of the engine was 52; the engine itself, without cooling water or fuel, weighed approximately 1 kilogramme to the horse-power. The entire power plant, including cooling water, carbureter, battery, etc., weighed materially less than five pounds to the horse-power. Engines for both the large machine and the quarter-size model were completed before the close of 1901, and they were immediately put in their respective frames and tests of them and their power-transmission appliances were begun.

INSTANTANEOUS PHOTOGRAPH OF THE LAUNCH OF OCTOBER 7, 1903.

It is well here to call attention to the fact that although an engine may develop sufficient power for the allotted weight, yet it is not at all certain that it will be suitable for use on a machine which is necessarily as light as one for traversing the air, for it would be impossible to use, for instance, a single-cylinder gasoline engine in a flying machine unless it had connected to it prohibitively heavy flywheels. These facts being recognized, the engines built in the Smithsonian shops were provided with five cylinders, and it was found upon test that the turning effect received from them was most uniform, and that, by suitable balancing of rotating and reciprocating parts, they could be made to work so that there was practically no vibration, even when used in the very light frames of the aerodromes.

The engine is not all the apparatus connected with the development and delivery of power, for obviously there must be shafts, bearings, and in the present case there were also gears; and all of these parts must necessarily be phenomenally light, while all of the materials must be capable of withstanding repeated and constant strains far beyond their elastic limit. It is also evident to anyone having familiarity with such constructions that it is most difficult to keep the various bearings, shafts, gears, etc., in proper alignment without adding excessive weight, and also that when these various parts once get out of alignment when subject to strain, the disasters which are caused render them unfit for further use.

The engines themselves were successfully completed before the close of 1901, and were of much more power than those originally designed; but nearly a year and a half had been spent not only in their completion, but in properly co-ordinating the various parts of the frame carrying them, repairing the various breakages, assembling, dismounting, and re-assembling the various parts of the appliances, and in general rebuilding of frame and appurtenances to correspond in strength to the new engines.

There are innumerable other details, for the whole question is one of details. I may, however, particularly mention the carbureters, which form an essential part of every gas engine. Such giving fair satisfaction for use in automobiles were on the market at the time, yet all of them failed to properly generate gas when used in the tests of the engine working in the aerodrome frame, chiefly because of the fact that the movement of the engine in this light frame must be constant and regular or the transmission appliances are certain of distortion. It was, therefore, necessary to devise carbureters for the aerodrome engines which would meet the required conditions, and more than half a dozen were constructed which were in advance of anything then on the market, and yet were not good enough to use in the aerodrome, before a satisfactory one was made. These experiments were made in the shop, but with an imitation of all the disturbing influences which would be met with in the actual use of the machine in the air, so as to make certain, as far as possible, that the first test of the machine in free flight would not be marred by mishaps or unseen contingencies in connection with the generation and use of power.

It is impossible for anyone who has not had experience with such matters to appreciate the great amount of delay which experience has shown is to be expected in such experiments. Only in the spring of 1903, and after two unforeseen years of assiduous labor, were these new engines and their appurtenances, weighing altogether less than five pounds to the horse-power and far lighter than any known to be then existing, so co-ordinated and adjusted that successive shop tests could be made without causing injury to the frame, its bearings, shafts, or propellers.

And now everything seemed to be as nearly ready for an experiment as could be until the aerodrome was at the location at which the experiments were to take place. The large machine and its quarter-size counterpart were accordingly placed on board the large house-boat, which had been completed some time before and had been kept in Washington as an auxiliary shop for use in the construction work, and the whole outfit was towed to a point in the Potomac River, here three miles wide, directly opposite Widewater, Va., and about forty miles below Washington, and midway between the Maryland and Virginia shores, where the boat was made fast to moorings which had previously been placed in readiness for it.

Although extreme delays had already occurred, yet they were not so trying as the ones which began immediately after the work was thus transferred to the lower Potomac.

The object in constructing the quarter-size counterpart of the large machine was to duplicate in it the balancing and relative proportions of power, surface, etc., that had been arranged in the large one, so that a test of it might be made which would determine whether the large machine should be tried as arranged or the balancing and other arrangements modified. The launching apparatus, which had proved so eminently successful with the original steam-driven models in 1896, was considered a thing so well tested that it had, as I have stated, been duplicated on a suitable scale for use with the large aerodrome, and it was felt that if this apparatus were exactly similar to the smaller one it would be the one appliance least likely to mar the experiments.

In order to test the quarter-size model it was necessary to remove its launching track from the top of the small house-boat and place it upon the deck of the large boat, in order to have all the work go on at one place, as it was impossible, on account of its unseaworthiness, to moor the small house-boat in the middle of the river.

While this transfer of the launching apparatus from the small boat to the large one was being made, the changed atmospheric conditions incident to a large body of water over which thick fogs hung a great portion of the time, from those of a well-protected shop on the land, began to manifest themselves in such ways as the rusting of the metal parts and fittings, and the consequent disarrangement of the adjustment of the necessarily very accurate pieces of apparatus connected with the ignition system of the engine. These difficulties might have partly been anticipated, but there were others concerning which the cause of the deterioration and disarrangement of certain parts and adjustments was not immediately detected, and consequently when short preliminary shop tests of the small machine were attempted just prior to launching it, it was found that the apparatus did not work properly, necessitating repairs and new constructions and consequent delay. Although the large house-boat with the entire outfit had been moved down the river on July 14, 1903, it was not until the 8th of August that the test of the quarter-size model was made, and all of this delay was directly due to changed atmospheric conditions incident to the change in locality. This test of the model in actual flight was made on the 8th of August, 1903, when it worked most satisfactorily, the launching apparatus, as always heretofore, performing perfectly, while the model, being launched directly into the face of the wind, flew directly ahead on an even keel. The balancing proved to be perfect, and the power, supporting surface, guiding, and equilibrium-preserving effects of the rudder also. The weight of the model was 58 pounds, its sustaining surface 66 square feet, and the horse-power from 2½ to 3.

This was the first time in history, so far as I know, that a successful flight of a mechanically-sustained flying machine was made in public.

The flight was not as long as had been expected, as it was found afterward that one of the workmen, in his zeal to insure an especially good one, had overfilled the gasoline tank, which would otherwise have enabled a flight several times as long. However, as such a flight would have given absolutely no more data than the short one did, and as the delays in getting ready for testing the large machine had already far exceeded what was expected, it was thought best not to make any more tests with the small one, as all of the data which were desired had been procured, and it was accordingly stored away and every energy immediately concentrated in getting the large machine ready for its first test, which at that time seemed only a few days away.

During all these delays it may be remarked that we necessarily resided near the house-boat, and therefore in a region of malaria, from whose attacks a portion of us suffered.

I have spoken of the serious delays in the test of the small machine caused by changed atmospheric conditions, but they proved to be almost negligible compared with what was later experienced with the large one. I have also alluded to the fact that the necessarily light ribs of the large sustaining wing surfaces were covered with several coats of a special marine varnish which many tests had shown enabled the glue to withstand submersion in water for more than twenty-four hours without being affected. This water test was made with a view to guarding against the joints of the ribs being softened when the machine came down into the water, as it was planned for it to do at the close of its flight, and these submersions had apparently shown that no trouble need be anticipated from the effects of the sustaining surfaces getting wet. It is an instance of the unpredictable delays which present themselves, that when preparations had been begun for the immediate trial of the large machine, already down the river, it was found that every one of the cross ribs had been rendered almost useless by the damp, though under shelter. As it would take months to build new ones, a temporary means of repairing them was used. There were other delays too numerous to mention, but chiefly incident to working over the water, some of the principal of which were due to storms dragging the house-boat from its moorings and destroying auxiliary apparatus, such as launches, boats, rafts, etc., to say nothing of the time consumed in bringing workmen to and from the scene of the experiments. The propellers were even found to break under the strain of the actual engines in the open, though they had not done so in the shop, and this is mentioned as another instance of the numerous causes of trying delay which it was impossible to foresee.

Finally, however, on the 3d of September, everything seemed to be in readiness for the experiments, and the large aerodrome was accordingly placed in position and all orders given and arrangements made for a test that day. After stationing the various tugs, launches, etc., at their predetermined positions so that they might render any assistance necessary to the engineer or the aerodrome, in case it came down in the water at a point distant from the house-boat, and after the photographers, with special telephoto cameras, had been stationed on the shore in order that photographs with their trigonometrical data might be obtained, from which speed, distance, etc., might be later determined, and when everyone was anxiously expecting the experiment, a delay occurred from one of the hardly predictable causes just mentioned in connection with the weather. An attempt was made to start the engine so that it might be running at its proper rate when the aerodrome was launched into free air after leaving the track, but the dry batteries used for sparking the engine, together with the entire lot of several dozen which were on hand as a reserve, had become useless from the dampness.

I have merely instanced some of these causes of failure when everything was apparently ready for the expected test, but only one who was on the spot and who had interest in the outcome could appreciate trials of this sort, and the delays of waiting for weather suitable for experiments.

It was found that every storm which came anywhere in the vicinity immediately selected the river as its route of travel, and although a ten-mile wind on the land would not be an insurmountable obstable during an experiment, yet the same wind on the river rendered it impossible to maintain the large house-boat on an even keel and free from pitching and tossing long enough to make a test.

While speaking of the difficulties imposed by the weather, it should also be understood that to take the aerodrome in parts from under the shelter of the roof and assemble and mount it upon the upper works was a task requiring four or five hours, and that during this time a change in the weather was altogether likely to occur, and did repeatedly occur, sufficient to render the experiment impossible. Experience has shown, then, that the aerodrome should be sheltered by a building in which it shall be at all times ready for immediate launching. During all the delay resulting from this and other causes—since it was never known on what day the experiment might take place—a great expense for tugboats waiting at a distance of forty miles from the city was incurred, and this was a part of the continuous drain on the pecuniary resources, which proved ultimately more fatal than any mishap to the apparatus itself.

Following the 3d of September, and after procuring new batteries, short preliminary tests inside the boat were made in order to make sure that there would be no difficulty in the running of the engine the next time a fair opportunity arrived for making a test of the machine in free flight. Something of the same troubles which had been met with in the disarrangement of the adjustments of the small engine was experienced in the large one, although they occurred in such a different way that they were not detected until they had caused damage in the tests, and these disarrangements were responsible for broken propellers, twisted shafts, crushed bearings, distorted framework, etc., which were not finally overcome until the 1st of October. After again getting everything in apparent readiness, there then ensued a period of waiting on the weather until the 7th of October (1903), when it became sufficiently quiet for a test, which I was now beginning to fear could not be made before the following season. In this, the first test, the engineer took his seat, the engine started with ease and was working without vibration at its full power of over 50 horse-power, and the word being given to launch the machine, the car was released and the aerodrome sped along the track. Just as the machine left the track, those who were watching it, among whom were two representatives of the Board of Ordnance,* noticed that the machine was jerked violently down at the front (being caught, as it subsequently appeared, by the falling ways),† and under the full power of its engine was pulled into the water, carrying with it its engineer. When the aerodrome rose to the surface it was found, that while the front-sustaining surfaces had been broken by their impact with the water, yet the rear ones were comparatively uninjured. As soon as a full examination of the launching mechanism had been made, it was found that the front portion of the machine had caught on the launching car, and that the guy post, to which were fastened the guy wires which are the main strength of the front surfaces, had been bent to a fatal extent. The machine, then, had never been free in the air, but had been pulled down as stated.

The disaster just briefly described had indefinitely postponed the test, but this was not all. As has been said before, the weather had become very cold and the so-called equinoxial storms being near it was decided to remove the house-boat at the earliest time possible, but before it could be done, a storm came up and swept away all the launches, boats, rafts, etc., and in doing so completely demolished the greater part of them, so that when the house-boat was finally removed to Washington, on the 15th of October, these appurtenances had to be replaced. It is necessary to remember that these long series of delays worked other than mere scientific difficulties, for a more important and more vital one was the exhaustion of the financial means for the work.

Immediately upon getting the boat to Washington the labor of constructing new sustaining surfaces was begun, and they were completed about the close of November. It was proposed to make a second attempt near the city, though in the meantime the ice had formed in the river. However, on the 8th of December, 1903, the atmosphere became very quiet shortly before noon and an immediate attempt was made at Arsenal Point, quite near Washington, though the site was unfavorable. Shortly after arriving at the selected point everything was in readiness for the test. In the meantime the wind had arisen and darkness was fast approaching, but as the funds for continuing the work were exhausted, rendering it impossible to wait until spring for more suitable weather for making a test, it was decided to go on with it if possible. This time there were on hand to witness the test, the writer, members of the Board of Ordnance, and a few other guests, to say nothing of the hundreds of spectators who were waiting on the various wharves and shores. It was found impossible to moor the boat without a delay which would mean that no test could be made on account of darkness, so that it was held as well as possible by a tug, and kept with the aerodrome pointing directly into the wind, though the tide, which was running very strong, and the wind, which was blowing ten miles an hour, were together causing much difficulty. The engine being started and working most satisfactorily, the order was given by the engineer to release the machine, but just as it was leaving the track another disaster, again due to the launching ways, occurred.‡ This time the rear of the machine, in some way still unexplained, was caught by a portion of the launching car, which caused the rear sustaining surfaces to break, leaving the rear entirely without support, and it came down almost vertically into the water. Darkness had come before the engineer, who

* Major Macomb, of the Board of Ordnance, states in his report to the Board, that "the trial was unsuccessful because the front guy post caught in its support on the launching car and was not released in time to give free flight, as was intended, but, on the contrary, caused the front of the machine to be dragged downward, bending the guy post and making the machine plunge into the water about 50 yards in front of the house-boat."

† This instantaneous photograph, taken from the boat itself and hitherto unpublished, shows the aerodrome in motion before it had actually cleared the house-boat. On the left is seen a portion of a beam, being a part of the failing ways in which the front wing was caught, while the front wing itself is seen twisted, showing that the accident was in progress before the aerodrome was free to fly.

‡ Major Macomb again states in his official report to the Board: "The launching car was released at 4.45 P. M. . . . The car was set in motion and the propellers revolved rapidly, the engine working perfectly, but there was something wrong with the launching. The rear guy post seemed to drag, bringing the rudder down on the launching ways, and a crashing, rending sound, followed by the collapse of the rear wings, showed that the machine had been wrecked in the launching; just how it was impossible to see."

had been in extreme danger, could aid in the recovery of the aerodrome, the boat and the machine had drifted apart, and one of the tugs, in its zeal to render assistance, had fastened a rope to the frame of the machine in the reverse position from what it should have been attached and had broken the frame entirely in two. While the injury which had thus been caused seemed almost irreparable to one not acquainted with the work, yet it was found upon close examination that only a small amount of labor would be necessary in order to repair the frame, the engine itself being entirely uninjured. Had this accident occurred at an earlier period, when there were funds available for continuing the experiments, it would not have been so serious, for many accidents in shop tests had occurred which, while unknown to the general public, had yet caused greater damage and required more time for repair than in the present case. But the funds for continuing the work were exhausted, and it being found impossible to immediately secure others for continuing it, it was found necessary to discontinue the experiments for the present, though I decided to use, from a private fund, the small amount of money necessary to repair the frame so that it itself, together with its engine, which was entirely uninjured, might be available for further use if it should later prove possible, and that they themselves might be in proper condition to attest to what they really represent as an engineering achievement.

Entirely erroneous impressions have been given by the account of these experiments in the public press,

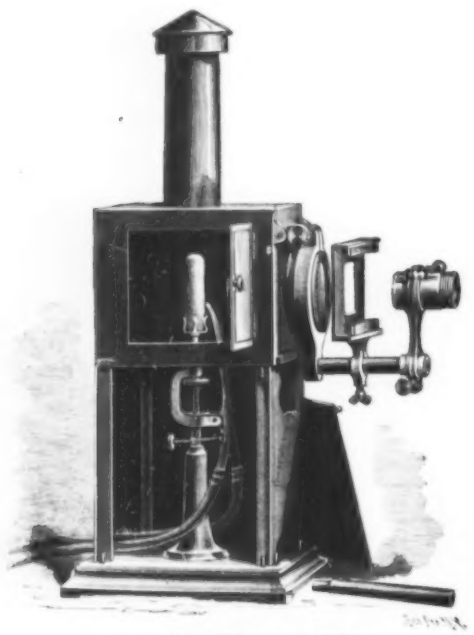


FIG. 1.—SCIENTIFIC LANTERN.

from which they have been judged, even by experts; the impression being that the machine could not sustain itself in flight. It seems proper, then, to emphasize and to reiterate, with a view to what has just been said, that the machine has never had a chance to fly at all, but that the failure occurred on its launching ways; and the question of its ability to fly is consequently, as yet, an untried one.

There have, then, been no failures as far as the actual test of the flying capacity of the machine is concerned, for it has never been free in the air at all. The failure of the financial means for continuing these expensive experiments has left the question of their result where it stood before they were undertaken, except that it has been demonstrated that engines can be built, as they have been, of little over one-half the weight that was assigned as the possible minimum by the best builders of France and Germany; that the frame can be made strong enough to carry these engines, and that, so far as any possible prevision can extend, another flight would be successful if the launching were successful; for in this, and in this alone, as far as is known, all the trouble has come.

The experiments have also given necessary information about this launching. They have shown that the method which succeeded perfectly on a smaller scale is insufficient on a larger one, and they have indicated that it is desirable that the launching should take place nearer the surface of the water, either from a track upon the shore or from a house-boat large enough to enable the apparatus to be launched at any time with the wings extended and perhaps with wings independent of support from guys. But the construction of this new launching apparatus would involve further considerable expenditures that there are no present means to meet; and this, and this alone, is the cause of their apparent failure.

Failure in the aerodrome itself or its engines there has been none; and it is believed that it is at the moment of success, and when the engineering problems have been solved, that a lack of means has prevented a continuance of the work.

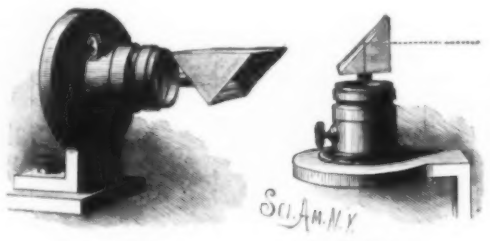


FIG. 5. FIG. 4.

APPLICATION OF THE 90-DEGREE PRISM.

THE SCIENTIFIC LANTERN.*

IN lantern projection, as in all other scientific work, the best results can be obtained only by employing the best means. While a cheap lantern may have considerable utility, it cannot fully satisfy modern requirements in the line of scientific projection. In Fig. 1 is illustrated a lantern which is adapted to all kinds of projection, and which may be readily shifted from

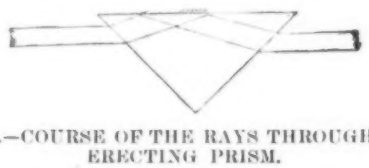


FIG. 6.—COURSE OF THE RAYS THROUGH THE ERECTING PRISM.

one kind of work to another. It is provided with an oxyhydrogen burner and with an electric lamp, either of which may be used at pleasure. It may be very quickly arranged as a vertical lantern, and all of the attachments are constructed so that they may be placed at once in the position of use without the necessity of alinement and adjustment in each case.

The frame of the lantern consists of cast-iron end pieces having rectangular legs attached to the base. To the sheet-iron top is attached a tall chimney, having a cowl at the upper end for confining the light. Opposite sides of the upper portion of the frame are provided with hinged sheet-iron doors. The lower part of the lantern frame is provided with hinged removable doors, which may be used to close in the light.

The front is furnished with a plate hinged to swing in a vertical plane, and provided with a cell for containing the outer lens of the condenser. The axis of this lens cell coincides with that of a similar cell supported by the front end piece of the frame and containing the inner lenses of the condenser. The inner lens of the condenser is a plano-convex 4 inches in diameter and of 8-inch focus, arranged with its plane side toward the light. The two outer lenses are plano-convex, 5 inches in diameter and 8 inches focus, arranged with the convex faces adjoining. The distance between the lenses is ¼ inch. The combined focal length is about 2 inches, measured from the plane face of the rear lens.

Prof. A. K. Eaton, of Brooklyn, has devised a condenser in which the inner lens is a meniscus and the outer and larger ones are crossed lenses. It is used in many scientific lanterns and is very effective.

* From "Experimental Science," by George M. Hopkins. Munn & Co., publishers, New York.

The outer or movable lens cell projects beyond the flanged plate, and receives a split ring provided with a shallow internal groove, which fits over a corresponding circumferential rib on the lens cell. This split ring has a tangent screw for drawing it together, so as to cause it to clamp the lens cell. It is also furnished with an ear, into which is screwed a bar parallel with the axis of the lens cell. To this bar are fitted the slide support, the supports of the projecting lenses, the apparatus for microscopic projection, the polariscope, the adjustable table for holding tanks, pieces of apparatus, etc.

As represented in Fig. 1, the lantern is arranged for the projection of pictures, diagrams, and such pieces of apparatus as will go in the place of an ordinary lantern slide. The objective is a one-quarter portrait lens of good quality. For the support of tanks and other vessels for projection, the table shown in Fig. 2 is used in place of the slide holder.

The attachments shown in Fig. 2 are employed for the projection of microscopic objects. The engraving shows the polariscope in place; but this may be removed by simply taking the short tubes which contain the prisms of the polarizer and analyzer out of the sleeves, *g*, *f*. The stage is arranged so that it may be revolved either with or independently of the polarizer, and the latter may be revolved independently of the stage. The objectives are supported by a movable plate, which swings so as to bring either of the objectives into the position of use. A small conically-pointed spring bolt locks the plate in either of its three positions. When it is desired to use a large objective, the plate may be swung below the supporting bar when the objective may be inserted in the sleeve, *f*. This arrangement admits of applying a system of lenses for wide-angled crystals.

In the projection of microscopic or polariscopic objects it is advisable to always interpose the alum cell or water tank, *h*, between the condenser and the

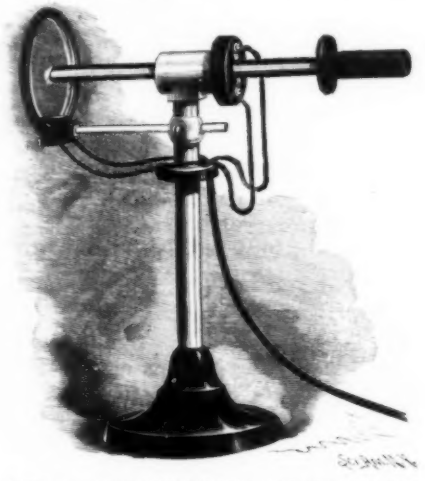


FIG. 7.—ARRANGEMENT OF ELECTRIC CANDLE FOR LANTERN USE.

Nicol prism or the object, to intercept the heat, and thus prevent injury to the prism or object.

The table, *i*, which supports the tank, *h*, is made adjustable as to height to accommodate different objects or pieces of apparatus. In front of the microscope attachment is supported a centrally apertured disk, which prevents stray light from reaching the screen.

The sleeve that supports the objective has a rack and the sleeve, *f*, slides on the tube, *a*, fitted to the support bar, and is provided with a pinion which meshes into the rack on the tube, *a*. By means of this pinion the objectives, together with the sleeve, *f*, are moved out or in for focusing.

In Fig. 3 is represented a polariscope for large objects, which is constructed according to the plan of Delezenne, but modified by the writer so as to utilize a right-angled totally reflecting prism, such as is used for presenting objects right side up on the screen; also for throwing the beam horizontally from the vertical attachment, as will be described later on.

The black glass polarizing mirror, *d*, is arranged at the polarizing angle in the path of the cone of light proceeding from the condenser. Below the mirror, *d*,

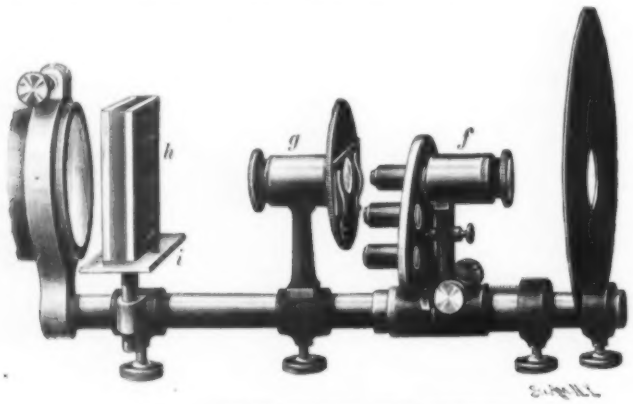


FIG. 2.—MICROSCOPE ATTACHMENT.

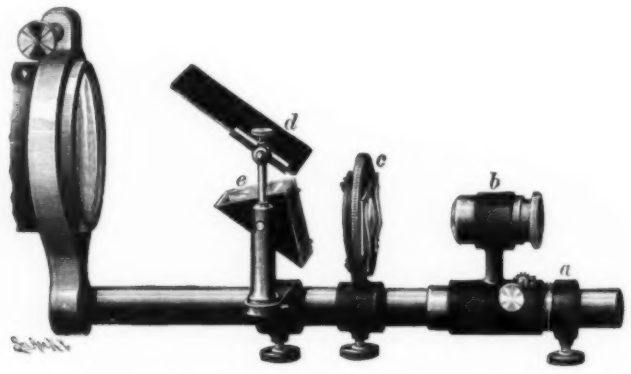


FIG. 3.—LANTERN POLARISCOPE.

is supported the right-angled prism with its reflecting side parallel with the mirror, *d*. The beam of light thrown downward by the black glass is thrown forward by the prism. A revoluble stage, *c*, and a tube, *d*, containing an objective and analyzing prism, are supported with their axes coincident with that of the light beam proceeding from the prism, *e*. Focusing is effected as in the other case. This arrangement is particularly adapted to the projection of designs in selenite or mica, mica cones, semi-cylinders, and specimens of stained glass.

There is an inappreciable loss resulting from the angle formed by the 90-degree sides of the prism with the incident and emergent beams. The polarizer works very perfectly, and costs only a small fraction of the amount required to purchase a Nicol prism of the same capacity. It cannot, of course, be revolved; but the object and the analyzer can be turned, which is sufficient. Very good results can be secured by employing a plane mirror in place of the reflecting prism. The bar which projects from the front of the lantern is made in two sections, connected by a close-fitting bayonet joint.

For such objects as must lie in a horizontal position when projected, the hinged plate which supports the outer half of the condenser is raised into a horizontal position, and a triangular casing containing a mirror is placed underneath it. The attachment is provided with short studs, which enter the front of the lantern and the hinged plate, and hold it in position. The reflecting prism (Fig. 5), or a plane mirror, is placed over the object to direct the light to the screen.

The improvements in the lantern and the attachments thus described are the result of a long experience with lanterns of various kinds. It is believed that it fulfills most requirements. It can readily be adapted to all the uses for which a scientific lantern is required.

To prevent the escape of stray light a wire frame is attached to the body of the lantern, so as to support a black cloth canopy, which covers the entire front of the lantern and extends downward below the support bar. It is provided with an aperture in front for the passage of the projected beam. In addition to this protection, the larger objectives may be provided with disks like that shown in Fig. 2. These precautions in regard to the escape of light are particularly necessary in microscopic and polariscopic projection, which re-

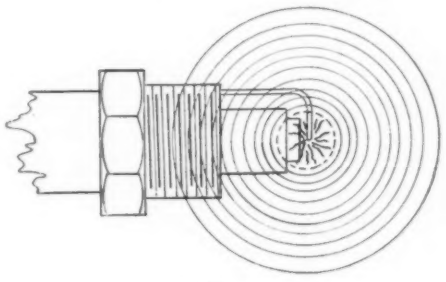


FIG. 1.

quire a thoroughly darkened room. In the projection of plain microscopic objects, it is found advantageous to place a plano-convex lens of three-fourths inch focus behind the stage.

An analyzer, formed of a series of three glass plates, and arranged to show both transmitted and reflected beams, is desirable. By a second reflection of the reflected beam it may be combined with the transmitted beam, showing that the reunion of the complementary colored beams produces white light.

In Figs. 4 and 5 are shown two applications of the 90-degree prism. In Fig. 4 it is shown in position for erecting the image produced by the lantern. The course of the rays is clearly indicated in Fig. 6.

The totally reflecting prism, when used to render the beam horizontal in a vertical lantern, is arranged as shown in Fig. 5, i. e., with one of its faces at right angles to the beam, and with its reflecting face at an angle of 45 deg. with the beam, or approximately so.

Probably the most desirable source of light for all purposes is the oxyhydrogen or calcium light. The burner shown in Fig. 1 is an excellent one. It is provided with a platinum-tipped jet and is arranged for every adjustment. The lime cylinder can be revolved and raised or lowered. The jet may be adjusted relatively to the lime so as to secure the best results. As the gases are mixed inside the burner, they should be taken from tanks or cylinders in which considerable pressure is maintained. Gas bags are unsafe when used in connection with a burner of this kind.

In the electric lamp shown in Fig. 7, a Jablochkoff candle is employed. It is superior to the calcium light, and gives very little trouble when an alternating current is available. The carbons being presented end on to the object yield nearly all their light in one direction, so that the loss of light is less than in the case of the ordinary arc lamp. The candle is coincident with the prolongation of the axis of a helix supported near the luminous point. The current that supplies the candle passes through the helix. In consequence of this the arc is drawn to the end of the candle in opposition to its tendency to follow the carbon rods. The candle can be moved forward as it is consumed by grasping the insulating handle at the rear end. Electrical contact is established with the rods by two copper springs contained in the revoluble support of the candle. When a direct current is used, a quick-acting current-reversing switch is required, as in this case the current must be reversed frequently to cause the carbons to burn evenly.

ELECTRIC IGNITION SYSTEMS.

By E. W. ROBERTS.

IN all electric ignition systems, with the exception of the catalytic, the mechanism must be one that will produce an electric arc within the compression space at the proper point in the piston stroke. In an electric circuit, if the current is made to pass through an air gap, the high resistance of the air raises the tempera-

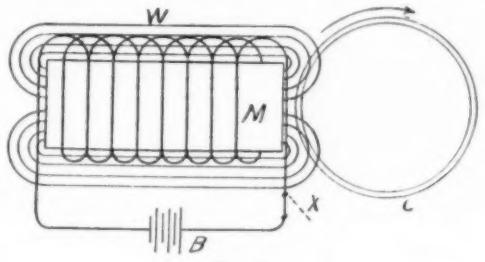


FIG. 2.

ture of the gap to such a degree that a spark is formed. The high temperature of the electric arc produced raises the surrounding gas to the temperature of ignition and it takes fire.

The reader should note that the spark sets fire to only that portion of the mixture which is in immediate contact with it. So soon as this small particle of gas is ignited, it in turn ignites another layer of gas and the flame proceeds through the mixture from layer to layer, as illustrated in Fig. 1.

In the figure the dotted circle immediately surrounding the spark represents the first layer ignited and from this point as a center the flame proceeds along the radii of a sphere having the spark at its center, until the farthest limit of the mixture is reached.

As might be supposed, there is a small interval of time elapsing from the moment when the spark is produced until the mixture is entirely in flame, and al-

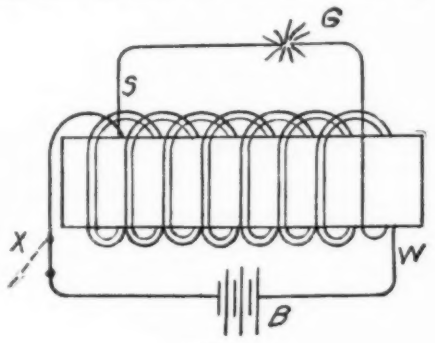


FIG. 3.

though this interval is but a fraction of a second it must be taken into account in the design and the adjustment of ignition apparatus. The time of inflammation depends upon several factors. These are the proportions of the mixture, the pressure at the time that ignition takes place, the location of the spark and the volume of the gas to be fired. In the automobile engine of average size and working under practically full impulse each revolution, the period of inflammation is approximately 1-120th second.

The period of inflammation is shorter, the higher the pressure, the richer the mixture, and the smaller the compression space. It is longer when the spark occurs in a recess or pocket than when the igniter points are placed nearer the center of the compression space. The length of the period is also affected to some extent

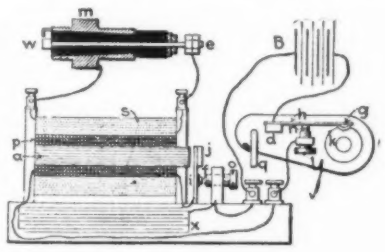


FIG. 5.

by the temperature of the spark, and whether it is so located that it is surrounded by fresh mixture or a mixture diluted by burned gases from a previous charge.

In order to secure the best effect from the explosion of gasoline vapor and air, the ignition is regulated to occur so far in advance of the end of the compression stroke that the mixture is fully inflamed, and in consequence the maximum pressure of explosion is obtained just as the piston starts on the expansion stroke. As the period of inflammation is the same under similar conditions, it will be seen that as the engine speeds up a revolution is made in much shorter time and ignition must take place earlier in the stroke. For instance, taking the average period of inflammation as 1-120th second, the lead of the igniter at 100 revolutions per minute should be 1-72d of one revolution, or ignition should take place when the crank has still 5 deg. to turn before reaching the dead center. Without considering the difference in the compression pressure when the piston is further from the end of the compression stroke, it is plain that for 200 revolutions per minute the advance of the igniter should be twice 5 deg., or 10 deg.; and for 600 revolutions per minute six times 5 deg., or 30 deg. Considering that at lower pressures the period of inflammation is longer, at higher speeds, with the same final compression pressure, the advance of the igniter should be slightly greater than 5 deg. per 100 revolutions per minute, as the above figure for the period of inflammation is based upon certain engines having 80 pounds final compression in which the best results were obtained with the igniter set at 30 deg. advance when the engine was running at 600 revolutions per minute.

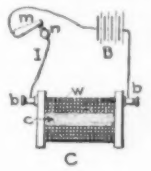


FIG. 4.

The reader should not forget that the pressure of the mixture has an important bearing upon the period of inflammation, and that when running at low speeds with the engine throttled down, better results may be obtained with more advance than called for by the above rule. But when running with full throttle at low speeds, as when climbing a grade upon the high gear, the spark should be retarded. The period of inflammation will be found slightly longer with jump-spark ignition than when using the hammer break, and is apparently shorter with a hot engine than with a cold one, as, for instance, it is less with an air-cooled engine than with a water-cooled engine.

In order to cause a current of electricity to bridge an air gap and hence produce an electric arc, some means must be provided of either producing a current of sufficient voltage to overcome the resistance of the gap or to reduce resistance of the gap. Under ordinary conditions at atmospheric pressure it requires a pressure of 20,000 volts to cause the current to bridge an air gap one inch long. As, for shorter distances, the voltage required is very nearly in proportion to the length of the gap, it would require a pressure of 625 volts to force a current across a gap 1-32 inch wide. Under higher pressure than that of the atmosphere, a still higher voltage is required. As 1-32 inch is the usual gap over which the current must flow in order to produce the igniting arc, some means of providing a high tension current must be provided. This is accomplished in all forms of electric-arc ignition by increasing the tension of a battery or a dynamo current, either by the reaction of an inductive circuit at the moment of breaking it or by means of a Ruhmkorff coil. The first is the principle of the hammer-break igniter and the latter the principle of the jump-spark system. In the hammer-break system the circuit is broken inside the cylinder, while in the jump-spark system the terminals within the cylinder are stationary and a high-tension impulse, produced without the cylinder, causes the current to bridge the gap.

If, as shown in Fig. 2, an electric conductor forming a complete circuit, as for instance a circuit loop of wire with the ends jointed, as shown at *C*, so placed in the field of a magnet that the conductor crosses the magnetic lines of force which are supposed to emanate from the poles of the magnet, a current will be produced in the conductor at every change in the strength of the magnetic field, and this change in the strength of the magnetic field may be produced either by increasing or decreasing the strength of the magnet by

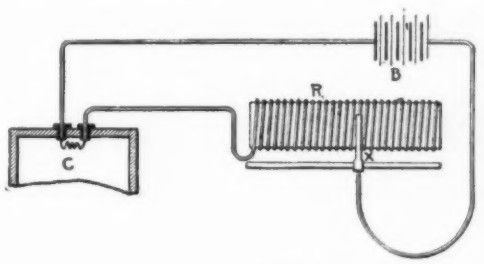


FIG. 6.

moving the magnet past the conductor or by moving the conductor past the magnet.

About every circuit through which a current is flowing, there is a magnetic field, the strength of which is directly in proportion to the strength of the current. If a wire through which the current is flowing is wound about an iron core, preferably a bundle of soft iron wires, the magnetic field is generally intensified, and the combination then becomes an electro-magnet. Either increasing or decreasing the strength of the current will make a corresponding increase or decrease in the strength of the electro-magnet. Suppose that the conductor, *W*, in Fig. 2, is connected to some source of current as the battery, *B*. Then if the circuit be broken at some point as *X*, say by means of a switch,

the current strength will change from maximum to zero. The rapid demagnetizing of the magnet and the consequent drop in the strength of the magnetic field to practically nothing will cause a current to flow in the conductor, *C*. Not only the conductor, *C*, but conductor, *W*, crosses the path of the lines of force, they taking the direction as shown by the dotted lines. Therefore it is plain that not only is a current generated in *C*, but in the conductor, *W*, as well. The pressure of the current which is induced by changing the strength of the magnetic field is proportional not only to the change of the current strength but to the rapidity with which the change is made. Hence, breaking the current at *X* produces an induced current of high tension in the conductor, *W*, and this current, of high tension, will jump the short gap formed during the first break of the circuit at *X*. Note carefully that the magnetic field has been strengthened by means of the iron core and that a greater reactionary current is produced when a core of iron is present than when the coil, *W*, is not wound around an iron core. If the circuit is broken, as in the hammer-break igniter, within the cylinder of a gas engine, it produces a spark sufficient to ignite the charge. The pressure of the current produced in the coil is directly proportional to the number of turns of wire lying in the magnetic field. Suppose that about the conductor, *W*, in Fig. 2, there are wound several thousand turns of very fine wire, as shown at *S* in Fig. 3. Then when the circuit, *W*, is broken at *X*, a current of very high tension is produced in the fine wire winding strong enough to jump across the gap, *G*. If the gap, *G*, were inside the cylinder of the gas engine, as in the spark plug of the jump-spark system of ignition, there will be sufficient heat generated to ignite the charge.

In Fig. 4 is shown in greater detail the principles of the hammer-break system of ignition. The coarse wire winding, *w*, say N. 16 gage, is wound about a core, *c*, consisting of a bundle of soft iron wires, the ends of the wire, *w*, being attached to the binding posts, *b b*. One of these binding posts is connected to a terminal of the battery, *B*, and the other by means of the wire, *l*, to the stationary electrode of the igniter. This electrode is insulated from, i. e., kept out of electric contact with the cylinder of the engine. The other terminal of the battery is connected to the electrode, *m*, or as *w* is in electric contact with the engine, this wire may be connected to any point upon the ironwork of the engine. Both terminals, *m* and *n*, are within the compression space of the engine. Just before the time for ignition these terminals are brought together and the current then passes from *B* through the spark coil, *C*. At the proper moment for the ignition, *m* is jerked away from *n*, producing a quick break in the circuit and the relative spark already described. With reference to the spark coil *C*, it should be noted that it takes a small fraction of a second for the current to fully magnetize the core, *c*. Therefore the igniter points should be brought together a small fraction of a second before the time for ignition. The longer the coil, the longer time is required for the core to reach full magnetization, or in other words, to become fully magnetized. If the time the circuit is closed is too short, the resulting spark will be weaker than if the circuit is closed long enough for the core to be magnetized. A long spark coil requires a longer time to reach full magnetization than a short coil. Hence short coils should be used for high-speed engines and in automobile practice they should not be over 6 inches long, a 5-inch coil being preferred.

Diagram No. 5 illustrates the jump-spark system of ignition. The Ruhmkorff coil consists of a core, *a*, made of a bundle of soft iron wires, usually 22 gage, and surrounded by a primary, *p*, of coarse wire, usually 16 gage. About the primary winding is a secondary, *s*, consisting of a very long winding of exceedingly fine wire, quite frequently 36 gage. Opposite one end of the core, *a*, is a soft iron armature, *j*. Attached to the spring, *i*, are contact points of platinum, making a gap at *f*. In the base of the coil is a condenser, *x*, made of a number of layers of tinfoil separated from each other by oiled paper. Alternate layers of tinfoil form one side of the condenser and are electrically connected to the contact screw, *o*. The remaining layers of the condenser are electrically connected to the spring *i*. The spark plug consists of a brass or steel body, *m*, threaded at one end with a pipe thread for screwing into the cylinder and the central conductor, *c*, insulated from the body, *m*, by either mica, porcelain or some form of artificial stone, as lava. The insulation must necessarily be of high resistance in order to insulate the high-tension circuit of the secondary. Projecting from the threaded end of the body, *m*, is a wire terminal, made usually of platinum or German silver and approaching but not quite meeting the left-hand end of the central conductor, *c*, forming a gap at *w*, about 1-32 inch wide. The contact maker consists of a body, *d*, on which is mounted a pillar carrying the adjusting screw, *y*, and another carrying the spring, *h*. Attached to the end of the contact screw and to the spring are platinum contact points forming a gap at *n*, similar to the one at *f* on the coil. On the end of the spring, *h*, is a knob, *g*, and on the cam shaft is a cam, *k*, having a notch at one point in its circumference. A rod, *q*, connected to the operating lever is used to rotate *d* around the cam shaft.

The operation of the system is as follows: The current passes from the source of energy, the battery, *B*, to the spring, *h*, by the gap, *n*, to the adjusting screw, *y*, thence through one of the binding posts of the coil to one end of the primary winding. The other terminal of the battery is connected to another binding post of the coil, thence it passes to the adjusting screw, *o*, crosses the gap, *f*, goes on through the spring, *i*, and to the other terminal of the primary. As the cam revolves the knob, *g*, falls into the notch and the contact points at *n* come together, closing the circuit to the primary. The moment the circuit is closed through the primary, the core, *a*, is magnetized, attracting the armature, *j*, breaking the circuit at *f*, and demagnetizing the core. When the core, *a*, is demagnetized, it releases the armature, *j*, and the spring, *i*, closing the circuit at *f*, when the operation is repeated. This, it will be seen, causes a rapid change in the strength of the magnetic field each time the circuit is broken at *f*. This magnetic variation induces a current in the coil, *s*; which, being composed of a great number of turns of a very fine wire, produces a high tension and a spark leaps the gap at *w*. So long as the vibrator is working, there will be a series of sparks occurring at *w*. The condenser, *x*, is connected across the gap, *f*, and its purpose is to reduce the volume of the spark at that point. When the circuit is broken at *f*, the conductor neutralizes the effect of the reaction. If it were not for the condenser a great deal of the energy would be wasted by producing a spark at *i*, and thus cut down the spark at the gap, *w*, of the spark plug.

In some coils, notably those used on the motor bicycle, the vibrator, *i*, is omitted, and but one spark is produced by breaking the circuit at *n*. With the vibrator coil, ignition takes place at the time the knob, *g*, falls into the notch in the cam. With the non-vibrator coil the point of ignition is when the knob is lifted from the notch. There is little or no spark at the time of breaking the circuit, for the reason that the change in the strength of the magnetic field is slower owing to the small interval of time it requires to magnetize the core, *a*. The advance of the spark is readily altered by rotating the contact maker around the cam shaft by means of the rod, *q*. If the contact maker is rotated in the same direction the cam shaft is revolving, ignition will occur later, while if it is rotated in the direction opposite to the motion of the cam shaft, the spark will be advanced.

The catalytic system of ignition is illustrated in Fig. 6. Catalytic defined, means "contact," and the system is nothing more than hot-wire ignition. The battery, *B*, of large current capacity, is connected in series with a coil of fine platinum wire, *C*, within the compression space. At *R* is shown a rheostat with a sliding contact, *X*. Sliding *X* to the left cuts down the resistance of the circuit and raises the temperature of the wire at *C*. The writer does not know of any commercial use of this system, it having been used only in an experimental way in Europe. It is said that by raising the temperature of the wire the ignition will be advanced and *vice versa;* therefore, the time of the ignition can be controlled by use of the sliding contact, *X*.

In comparison of the several systems of electric ignition it may be said that the objection to the primary or hammer break are the moving parts within the cylinder, the wear of the parts while operating at high speeds, and especially wear of the igniter points at the gap in Fig. 4, and it has a somewhat greater current consumption than the jump-spark system. The jump-spark system has the objection that there are more parts to take care of, that high tension makes insulation difficult, and the ignition plug is easily put out of commission by a crack in the insulation. However, for a variable lead the jump-spark system is easier to manipulate and has all the moving parts at the outside of the cylinder, where they may be kept cool and are easy to get at and adjust when the engine is running. It may be said of the hammer-break system that when it is arranged for variable lead there is very nearly, if not quite, as much mechanism involved as with the jump-spark system. As a matter of fact, the writer's opinion is that the jump spark has a slight advantage over the hammer-break, but that both of them are equally effective for high speeds. However, when it comes to igniting multiple-cylinder engines, the jump-spark system has an advantage over the hammer-break in the simplicity of mechanism, because one contact box can be made to answer for all the cylinders. In regard to the catalytic system, it is so new and untried that it is too soon to compare it with the systems using the electric arc.—Automobile Review.

ELECTRICALLY-HEATED CARBON TUBE FURNACES.*

PART I.

By R. S. HUTTON, M.Sc., and W. H. PATTERSON, B.Sc.

IT is surprising, when the importance of the subject is considered, how very little laboratory work has been done with the electric furnace under properly adjusted and fixed temperature conditions in those higher regions of temperature where the electrical is practically the only possible method of heating. Up to 1,300 deg. C. the furnaces in which an electric current passes through a nickel or platinum wire have fully proved their usefulness, while in the case of experiments of short duration platinum wire or foil heating coils have been employed for temperatures up to about 1,600 deg. C., but seemingly suffer very rapid deterioration when used for any length of time under these conditions. The iridium tube furnace of Nernst and Heraeus, even where its high cost is not prohibitive, seems to be unsuited† for all but the most delicate of experiments, although with it temperatures up to 2,100 deg. C. can be attained. Mention might also be made of the oxy-hydrogen furnace at Moissan‡ and the oxy-retort-graphite and water-gas furnaces of Victor Meyer and H. Biltz,‡ since these have served for somewhat delicate work, but, of course, in these cases the temperature conditions are not so fixed as when electrical heating is employed.

Several workers have recently employed furnaces constructed with a carbon tube through which an electric current is passed.‡ This type of furnace seems to be the most readily available for the very highest temperature; despite some inherent disadvantages due to the presence of carbon, it is capable of very wide application.

The authors do not propose to claim any superiority§ of their types of carbon tube furnaces over those constructed by other workers. As, however, they have been able to get satisfactory results with a very simple type of construction, they thought that a brief account of their preliminary work in this direction might be of some general interest.

General Considerations.—The most important points in the construction of carbon tube furnaces are, first, the provision of a satisfactory device for leading the current to the ends of the tube, and, secondly, the protection of the tube from contact with the air or other material capable of reacting with the carbon to burn it away. It is, moreover, a very great advantage to closely jacket the tube with some substance which, while not tending to combine with the carbon, forms an efficient heat-insulator. Even with the most carefully constructed system of exterior concentric tubes with intermediate gas spaces a great amount of heat is carried away by convection currents in the gases, and consequently much more power has to be expended in the tube to attain any required degree of temperature than when the tube is closely jacketed by some material of low thermal conductivity.

The connections at the ends of the tubes should be so constructed as to remain sufficiently cool to prevent any oxidation of that part of the carbon which is exposed to the air. Moreover, provided the ends are kept cool, it is an easy matter to make a gas-tight joint for the passage of any desired gas through the tube.

Graphite Tube Furnace.—The first furnaces made use of were constructed of Acheson graphite, a tube being bored from a solid rod of about 3 centimeters diameter, as shown in Fig. 1. Doubtless, when only a few experiments have to be carried out, this method of construction has its advantages. Blocks and rods of graphite are so frequently required in experimental electric furnace work, that the necessary material is almost sure to be at hand in any laboratory where such furnaces are wanted; whereas the methods of construction, to be described later, require a special provision of carbon tubes of the particular dimensions suitable for the current and power available. The tube was screwed to graphite plates, which served to lead in the current, the graphite plates being held between thick copper clamps, mounted on stands capable of sliding on a smooth plank; to these clamps the cables were connected. One of the sliders was balanced so as to more easily admit of expansion of the tube without fear of breakage. For heat insulation the graphite tube was surrounded with magnesia, or, later, carborundum held in place by brickwork not shown in the figure. On account of the very great shrinkage of calcined magnesia this material was not found satisfactory as a jacketing material. After the tube has been in use for a short time fissures are formed, which allow the air to come into contact with the carbon, and consequently considerably curtail its life; probably by using fused magnesia in the form of powder, better results could be obtained, and experiments in this direction are now in progress.

Both for these graphite tubes and also for the forms of furnace described later, carborundum has been found to be an excellent jacketing material. It is a fairly good heat-insulator, and has the advantage of being a reducing agent, consequently protecting the carbon from burning away. This material has been used in a fine granular condition (the grains just passing through a sieve 180 meshes to the linear inch). So soon as the graphite has attained a fairly high temperature, these grains frit together, forming an adherent, tube-shaped jacket around the graphite, which serves to strengthen and protect it.

The material to be heated in this furnace is placed in a small boat made of graphite or ordinary agglomerated carbon, the bottom of the boat being shaped so as to touch the tube at only a few points, and thus not itself to conduct any appreciable amount of the current.

The temperature is estimated by having a number of small carbon holders on each side of the boat, with pieces of various metal wires placed upright in them.¶

At approximately the melting-point of the metal the wire sinks and disappears from view. For higher tem-

* A paper read before the Faraday Society on Tuesday, April 4, 1905.

† W. Nernst, Trans. Amer. Electrochem. Soc. iii. 75 (1903); Z. Elektrochem. ix. 633 (1903). W. C. Heraeus, Z. angew. Chemie, 1905, 49-53.

‡ H. Moissan, Ann. de chim. et de phys. Sér. 7, xxiv. 289 (1901).

‡ V. Meyer and M. von Recklinghausen, Berichte, xxx. p. 1926 (1897). H. Biltz, Z. physik. Chem. xix. 385 (1896).

‡ F. Haber, "Grundriss der Techn. Elektrochemie" Munich, (1898), p. 380. Lummer and Pringsheim, Ber. deutschen. Phys. Gesell. 1903, 3. H. N. Potter, U. S. A. patents 715,506 to 715,509, Dec. 9, 1902, and 756,899, April 12, 1904.

§ In particular, the construction of some of the furnaces of Mr. H. N. Potter is obviously more perfect in many of the essential details; although probably they could not very easily be made and installed for ordinary laboratory work.

‖ For instance, one of the smaller tubes, after ten or twelve experiments, in nearly all of which it had been heated well above the melting-point of platinum, was found to have altered only to a quite insignificant extent in internal and external diameter.

¶ The practical constancy of temperature throughout the central portion of the tube was determined by having a number of small bends containing projecting nickel wires at regular intervals, and noting, when the temperature was slowly raised, that those in the central 15 centimeters melted at very nearly the same time.

peratures little cones of pure alumina or magnesia have been used, but more recently an optical pyrometer has been obtained, which it is hoped will prove very serviceable for experiments of this kind. The thicker ends of the graphite tube and the graphite plates get too hot to admit of a rubber or cork stopper being used; the glass tubes which serve for the gas inlet and outlet were therefore fixed with a plug made of fine asbestos string.

Agglomerated Carbon Tube Furnaces.—Where a considerable amount of work has to be done, the time necessary for boring and turning graphite tubes, which on account of the thin walls are always mechanically weak, is obviously a disadvantage. For most of our experimental work, therefore, we have made use of agglomerated carbon tubes, which can readily be obtained of almost any desired size from the several manufacturers of arc carbons. The amorphous carbon, being very hard, cannot be machined in the simple manner which is possible with graphite, and even grinding with carborundum wheels is a somewhat laborious operation; it was therefore decided to adopt a quite different method of making the electrical connections.

The construction finally adopted has proved itself so excellent in actual use that we believe it to be capable of wide application in electric furnace work, and have already adopted it for several types of resistance core furnaces.

The ends of the carbon tube, which may with advantage be somewhat roughened by filing, are electro-coppered, and then soft-soldered to thick copper tubes just large enough to slip over them. The copper tube is provided for a short distance with a brazed-on water jacket, which effectively cools the joint and protects it, even when very high current-density is necessary; at the further end of the copper tube a copper clamp connected with flexible cables leads in the current. By soft-soldering the carbon to copper tubes with brazed water jackets, it is always possible to easily replace the carbon without any fear of injuring the joints of the water jacket. The length over which the soldered joint has to be made obviously depends on the size of carbon tube and the strength of current to be sent through it, but with this water cooling the necessary surface of contact is surprisingly small.*

For the earlier experiments, carbon tubes 30 centimeters long, 15 millimeters internal, and 20 millimeters external diameter were employed; these were jacketed as before with carborundum, which was generally kept in place with an external asbestos tube and asbestos washers fitting tightly up against the ends of the water jackets.

A similar construction has been used with much larger tubes (60 centimeters long, 67 millimeters internal, and 82 millimeters external diameter), as

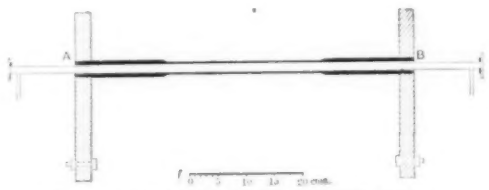


FIG. 1.—GRAPHITE TUBE FURNACE.

The tube is bored and turned from a solid rod, and is screwed at the ends into graphite plates (2.6 x 5.2 centimeters), which are clamped to copper holders not shown. The glass extensions, which are fixed into the graphite tube at *A* and *B* by asbestos, serve for the passage of gas through the tube; the plate-glass ends enable the progress of the experiment to be observed from either end. The central portion of the tube is surrounded with corborundum, or other heat-insulator, not shown in the figure. The material to be heated is placed in small carbon boats which are advanced to near the center of the tube.

shown in Fig. 2. The horizontally placed tube is capable of taking a number of small crucibles containing the material to be heated, but it is hoped to use these and still wider tubes in a vertical position, in which case a useful means of heating larger crucibles will be available. With these large tubes it is advisable to use some sort of diaphragm near the ends to prevent the radiated heat from burning the surface of the rubber or cork stoppers, which, as the copper is effectively cooled by the water jacket, can serve to attach the gas inlet and outlet extensions; with the small tubes there is no need to take this precaution.

During the past few months tube furnaces of this simple type have been in constant use and have been found to work with satisfaction. The rapidity with which a very high temperature can be obtained and the regulation of that temperature by simple variation in the strength of the current render their use very convenient. On the other hand, by starting with a relatively small current it is possible to raise the temperature as slowly as desired and thus not to exceed any required maximum. Without the more trustworthy data, which it is hoped to obtain by the use of the optical pyrometer, it does not seem advisable to hazard any estimate of the highest temperatures which can be reached with this method of heating.

Owing to the porosity of the carbon tubes at high temperatures, it is difficult, even with a fairly rapid current of hydrogen, to keep the gas in contact with the heated material free from carbon monoxide. Since this was highly desirable in some of the experiments we have been carrying out, a modified form of construction was adopted for this special case. In the first modification the carbon tube was surrounded with a water-cooled, gas-tight, metal jacket through which hydrogen was passed, but with this arrangement the convection currents in the external gas carry off an enormous amount of heat, and a very high current density is required to reach even moderately high temperatures. On the other hand, when the carborundum-jacketed tube is, as a whole, surrounded with the gas jacket, the gas in the inner tube still contains 1 or 2 per cent of carbon monoxide, which is probably due to the carborundum containing a small amount of unreduced silica. The arrangement finally adopted (see Fig. 3) has worked well, and is, moreover, considerably more efficient than when a bare carbon tube is surrounded with a large gas inclosure. The central carbon tube (30 centimeters long, 15 millimeters internal, 20 millimeters external diameter) forms the heating tube proper, and alone carries the current; it is surrounded by another carbon tube (3.0 centimeters internal diameter), which is jacketed with carborundum as a heat-insulator. Both carbon tubes are provided with water-cooled copper-tube extensions. Hydrogen is passed through the space between the two carbon tubes, as also through the inner carbon tube, and in this way it is easy to keep the gas in contact with the heated material almost absolutely free from oxygen compounds.

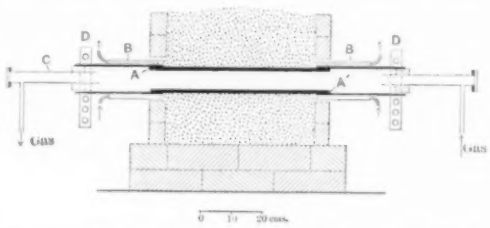


FIG. 2.—SIMPLE CONSTRUCTION OF AGGLOMERATED CARBON TUBE FURNACE.

The ends of the carbon are coppered and soldered at *A* and *A'* to copper tube extensions provided for a short distance with water jackets *B*, which keep the joint cool. The current is led in by copper clamps *D*. Glass tubes *C* are connected to the ends of the copper tubes by rubber stoppers, and serve for the passage of gas and for observation of the progress of the experiment. Smaller tubes of essentially the same construction have also been much used.

For a large number of purposes these precautions are quite unnecessary, and the simpler form of construction is all that is required; we have therefore ourselves confined the use of this furnace to some experiments in which it was desired to study the action of carbon on some metals without the intervention of carbon monoxide.

In all our experiments we have had to use continuous current, although obviously low-tension alternating current obtained by the use of a transformer would be much more convenient, particularly with the large-sized tubes.

In many laboratories the high currents required will certainly be a hindrance to the employment of such carbon tube furnaces, but in these cases it may be an advantage to increase the resistance of the tube by some such method as that proposed by E. Ruhstrat and E. W. Grimmer,* who cut a spiral on the carbon tube, and thus form a more or less narrow helix, which can be made to take quite small currents at correspondingly higher voltage.

In view of the prospect of shortly having fairly trustworthy data as to the temperature variations during the experiments, it is thought advisable to retain for a later paper full details as to the current and voltage readings at different temperatures. The following are only approximate values, which will, however, suffice to indicate the conditions under which the experiments have been carried out. The readings are those observed when the temperature indicated had been reached, and since the resistance obviously decreases as the temperature rises they must not be taken to indicate mean values.

Type of Furnace.	Jacketing material.	Observations.
Graphite; 28 cms. long, 2.6 external, 1.5 internal diameter.	Carborundum	295 amps. at 8.2 volts melts nickel in 26 mins.; 320 amps. at 9.6 volts melts nickel in 13 mins; platinum in 16½ mins.
Agglomerated carbon; 27 cms. long, 2 cms. external, 1.5 cms. internal diameter.	Carborundum	140 amps. at 7.7 volts melts nickel in 19 mins.; platinum in 28 mins.
Agglomerated carbon, 27 cms. long, 2 cms. external, 1.5 cms. internal diameter.	None; bare tube surrounded with hydrogen.	235 amps. at 16.4 volts required to melt nickel (5½ mins.)
Agglomerated carbon; dimensions, etc., as Fig. 3.	Carborundum outside outer carbon tube.	300 amps. at 21 volts melt nickel in 3 mins.; current increased to 240 amps. at 25 volts, melting platinum, in further 2½ mins.
Agglomerated carbon tube; 60 cms. long, 8.2 cms. external, 6.7 cms. internal (as Fig. 2).	Carborundum	600 amps. at 8.6 volts give 1,050° C. in 30 mins. (temp. still rising 7° per min.); 850 amps. at 13.0 volts melt nickel in 12 mins.; platinum in further 8½ mins.; later much hotter and takes 860 amps. at 11.1 volts.

* British patent 24,472, Nov. 18, 1903.

Important differences manifest themselves according to the type of furnace construction adopted. With a bare tube surrounded with a gas jacket, a given current very soon brings the carbon up to a temperature which remains more or less constant, or at the most only continues to rise very slowly; on the other hand, with carbons closely jacketed with a granular material, which is a good insulator, the temperature continues to rise for a very long time, and in this way, with a much smaller current and expenditure of power than is required in the previous case, a high temperature can be built up. As the temperature rises, however, the jacketing material becomes an electrical conductor, and even pure oxides at or near fusing-point become good conductors, and by carrying some of the current tends to limit the temperature attainable. Further experiments are required to show the relative behavior of different materials in this respect.

One of the great advantages of such furnaces over those in which the heat is obtained from an electric arc or a granular resistance material lies in the fact that the temperature can be much more easily regulated and kept constant.

There is such a vast amount of physical and chemical high-temperature work which can only be carried out when the heating is under perfect control that we feel confident in finding numerous applications for these carbon tube furnaces.

Electrochemical Laboratory, The University, Manchester.

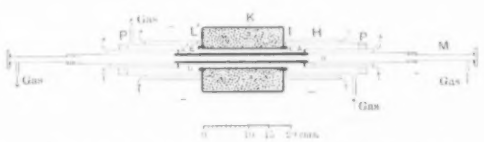


FIG. 3.—SPECIAL TUBE FURNACE FOR EXPERIMENTS IN PURE GAS ATMOSPHERE.

The central carbon tube *A A'* carries the current and is the heating tube proper; it is provided with copper water-cooled extensions *B C*, to which the current is led by clamps not shown. To insure the purity of the gas in the tube *A A'* it is surrounded by a concentric carbon tube *E E'*, which is also provided with copper water-cooled extensions *F H*, a gas-tight joint between the two tubes being made by the rubber stoppers *P*. The outer carbon tube is jacketed with a granular heat-insulator to prevent, as far as possible, the radiation of heat. This granular material is held in place by asbestos washers *L* and asbestos tube *K*. Glass extensions M serve as in Fig. 2 for the passage of gas through the heated tube, and for observing the progress of the experiment.

THE LATEST PERFORMANCES OF TYPICAL FRENCH, ENGLISH, AND AMERICAN AIRSHIPS.

ACCORDING to the old German and Swiss legend, the *Berggeister* were in the habit of invariably attempting to overwhelm the adventurous mountaineer who had the hardihood to attempt to climb previously unscaled peaks, by sending upon him at a critical moment thunderstorms, whirlwinds, and various kinds of avalanches. Once a peak had been scaled the *Berggeist* usually retired in dudgeon, and subsequent adventurers could essay the same road with comparative safety. It must be admitted that similar strange phenomena have been observed at every step in man's progress toward the conquest of natural forces. The attempts made upon the empire of the air provide plenty of instances of the kind, and two of the most painful of them have been illustrated by the history of the Lebaudy airship. It was just as "Lebaudy No. 1" had completed her tour from Moisson to Paris, and from Paris to Challais Meudon, and was actually alighting on the ground, that she was caught by a squall, hurled against a tree and broken up. Similar destruction overwhelmed the splendid airship at the end of her recent tour. She had made a record journey largely against the wind from Moisson to the camp of Chalons, encountering almost a storm during the latter stages of the tour, which, however, she succesfully surmounted, and arrived in triumph in Chalons Camp, where she had hardly been moored when the storm developed into a hurricane that even threw down telegraph poles. Moored in the open, no conceivable airship could stand a tempest of this kind, and it is certainly most singular that tempests of such ferocity are decidedly rare in the middle of France. The cables were pulled out of the hands of the thirty soldiers who held them and the airship was driven against some trees, causing the gas vessel to burst. Fortunately, the occupants of the car were within a few feet of the ground, and escaped practically uninjured. It is too soon to be certain whether the airship can or cannot be repaired, but in any case the designers and owners of the great machine—by far the most successful aeronautical contrivance, as our readers are aware, of modern times—may console themselves by the reflection that, like Gustavus Adolphus, "Lebaudy II." had won her battle when she met her end.

The irritating part about the situation is that it is quite possible the airship might have escaped injury had the hurricane come up while she was *en route*, as she might then have been able to run before it, and beat back when the violence of the storm was exhausted.

Messrs. Lebaudy and their collaborators have shown themselves such enthusiasts in the cause of aerial navigation that we feel confident that they will not be deterred by this very untoward and incalculable misfortune at the very moment of victory from prosecuting their experiments and researches further. We feel sure that before long a "Lebaudy No. 3" will rise from the ashes or remains of "Lebaudy No. 2." But the important question is whether it is really fair that private

* An experiment was carried out to test the perfection of these joints. One of the smaller tubes was surrounded with calcined magnesia, and heated with 200 amperes until the tube was practically completely destroyed. After cooling, the core was examined, and found to have burnt away to a mere shell right up to the copper; the joint, however was still undamaged, and not even a drop of solder had melted out of it.

individuals, however wealthy and enthusiastic, should be allowed to bear the whole brunt of the enormous expense involved in such experiments. The Lebaudy airship has fully demonstrated what it can do. A government representative, the head of its Aeronautical Department, or his chief assistant were on board all the time, and must report that no airship before has ever accomplished so much. It is certainly time that the French government and the national exchequer should come to the assistance of the plucky and enthusiastic experimenters. Indeed, the conquest of the air is not a merely national affair, and it would only be reasonable for the whole civilized world to assist in providing further sinews of war for what has already proved the most victorious campaign ever waged against the powers of the atmosphere.

It must not be forgotten that the chief contributing cause of the destruction was the absence of shelter at the Chalons Camp. An airship, however successful, which cannot rely upon an adequate shelter in which to take refuge at the end of its voyage, is like a vessel cruising round a perpetually rocky coast, destitute of a single harbor, and attempting to moor itself with cables to the sides of the cliffs. A vessel in such a position is obviously at the mercy of the first storm that gets up. The position of the "Lebaudy" on its tour was precisely similar. The only security it could obtain was that provided by its guide-ropes, and these are hopelessly inadequate in the case of a real storm. Even if the guide-ropes hold, the air pressure is bound to endanger the envelope which, unlike that of an ordinary spherical balloon, is already under a very considerable pressure. For navigable airships to be able to undertake extended tours of this kind without frequently running the risk of destruction, the erection of adequate sheds or shelters of some kind for housing them at the various points they propose to land, is a *sine qua non*, and this, it is plain, is an undertaking of national, if not international, magnitude.

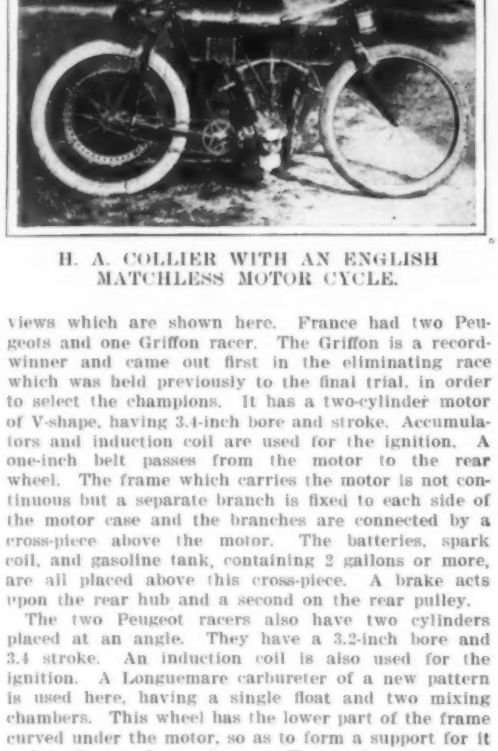
The Barton airship, which has for so long been lying inactive at the Alexandra Palace, took the air again recently, and made a short excursion on the guide rope. Dr. Barton and Mr. F. L. Lawson were both on board of her, and it is estimated that when the propellers were working properly she developed a forward speed of from 15 to 20 miles an hour. The vessel also appeared to obey the rudder most satisfactorily. There was a moment during the experiments when there seemed to be some danger of the big airship crashing into a tree, but the huge rudder was put well over, and had the effect of deflecting the airship away from this threatened danger.

On July 31 Leo Stevens made a successful ascension at Brighton Beach with the airship known as the "California Arrow." Despite the fact that a ¾-inch drag rope trailed along on the ground and over various trolley and electric light wires, the airship sailed majestically along, circling around the Brighton Beach Hotel and landing within a few feet of its starting place.

MOTOR CYCLE RACE FOR INTERNATIONAL CUP.

By the Paris Correspondent of SCIENTIFIC AMERICAN.

THE second annual race for the International Cup, which is organized by the Motorcycle Club of France, was held on the 25th of June. This is one of the best and most conclusive tests of motor cycles which has ever been held in Europe. As the roads were in good condition, there were no exterior circumstances to alter the character of the race, and we are thus able to fix upon the merits of the different motor cycles. These little machines made a remarkably fine performance, both as regards speed and endurance. The total distance was 150 miles, or five times around an elliptical circuit passing through Dourdan, not far from Paris, each round counting 30 miles. In the different towns a certain distance was deducted, and was not counted in the race. The actual racing distance was five rounds of 29.2 miles, or a total of 146 miles. Four different nations were entered in the contest, which made it decidedly of an international character. Each nation entered three of its best racing machines, which had been carefully chosen in previous trials. These machines represent the most recent progress in the way of motor cycles. Their construction is somewhat varied as may be remarked by the different views which are shown here. France had two Peugeots and one Griffon racer. The Griffon is a record-winner and came out first in the eliminating race which was held previously to the final trial, in order to select the champions. It has a two-cylinder motor of V-shape, having 3.4-inch bore and stroke. Accumulators and induction coil are used for the ignition. A one-inch belt passes from the motor to the rear wheel. The frame which carries the motor is not continuous but a separate branch is fixed to each side of the motor case and the branches are connected by a cross-piece above the motor. The batteries, spark coil, and gasoline tank, containing 2 gallons or more, are all placed above this cross-piece. A brake acts upon the rear hub and a second on the rear pulley.



H. A. COLLIER WITH AN ENGLISH MATCHLESS MOTOR CYCLE.

WONDRICK, THE WINNER, WITH AN AUSTRIAN LAURIN-KLEMENT MACHINE.

The two Peugeot racers also have two cylinders placed at an angle. They have a 3.2-inch bore and 3.4 stroke. An induction coil is also used for the ignition. A Longuemare carbureter of a new pattern is used here, having a single float and two mixing chambers. This wheel has the lower part of the frame curved under the motor, so as to form a support for it and is thus made continuous. Two brakes act on the back pulley, which is 16 inches in diameter. Two tanks are used, one for the gasoline containing 2 gallons, and a second for the oil.

England had three different makes entered, the "Matchless," "Ariel" and "J. A. P." We show a view of the Matchless wheel which was mounted by Collier. This machine is fitted with a twin-cylinder engine with automatic inlet valves having 1½ inches diameter. The cylinder bore is 3 inches and the stroke 4 inches. The carbureter is of the float-feed type with rose pattern jet, made entirely of aluminium. The wheel rims are of the same metal and carry Dunlap tires. The frame and brakes are so constructed that by loosening the axle nuts, either wheel can be dropped clear of the frame, so as to make repairs to the tires, etc. The contact-breaker is here placed on the motor case. An induction coil is used for the ignition. The machine is belt-driven by a Lincona belt ⅞ inch wide, with 6 and 16-inch pulleys. The Matchless machine has done the flying kilometer in 27 seconds, which is equal to a speed of 62 miles an hour. The Ariel machine has a two-cylinder motor which somewhat resembles the former, giving 6 horse-power. The cylinders are also mounted at an angle. It uses an Ariel carbureter, and an induction coil without a vibrator furnishes the jump spark. Above the cross-bar is mounted the cylindrical tank and below it is the spark-coil. This wheel was run by J. Campbell. It has a triangular belt passing from the motor pulley to the back wheel. The front part of the frame is braced by two additional supports. The third English machine, the "J. A. P.," has a two-cylinder motor of 3-inch bore and 3.8-inch stroke, and is claimed to give 6½ horse-power. It uses a Watawata belt upon pulleys which have a ratio of 1 to 2.8. The carbureter is of the Brown & Barlow pattern.

CISSAC ON A PEUGEOT RACER. THE PEUGEOT CAME IN SECOND.

The German team consisted of three "Progress" racers. These machines are all alike and have a low and elongated form. They are distinguished from the rest by the use of a single-cylinder motor, and, also by the use of a magneto for the ignition. Their cylinders have a set of large cooling flanges. A Longuemare carbureter is used with this machine. The triangular belt runs between 6-inch and 12-inch pulleys. Austria had three machines in the race. Two of them were of the Laurin-Klement make, and the third was of the Puch type. The somewhat peculiar shape of the Laurin-Klement racer will be noticed. The motor is supported by a curved piece which passes underneath it. This piece is joined to the rear of the frame by a horizontal bar. In the rear of the motor is the large gasoline tank, of square form, while the oil tank is separate and is placed at the top. The motor has 3-inch cylinder bore and 3.4-inch stroke. One peculiarity is the use of the magneto for the ignition and the latter is mounted in an inverted position underneath the motor. It is driven by chain from the motor shaft. The Puch racing motor-cycle has also a two-cylinder motor with 3-inch bore and 3.2-inch stroke, using a magneto driven from the motor.

There was thus a number of machines representing the latest progress made in each of the above countries in the way of motor cycles, and it is of interest to see how they compared with each other in the actual conditions of the race. The machines started off from a point near St. Arnoult at 10 o'clock A. M., led off by Demester, on a Griffon wheel, and followed two minutes apart by Carl Müller on a Progress wheel (Germany); J. Campbell, Ariel wheel (England); Toman, Laurin-Klement wheel (Austria); Guippone, on a Peugeot (France); Menzel, on a Progress (Germany); Collier, Matchless (England); Nikodem, Puch wheel (Austria); Cissac, Peugeot wheel (France); Jahn, Progress (Germany); Franklin, J. A. P. wheel (England); Wondrick, on a Laurin-Klement racer (Austria). At the end of the first round, Demester crossed the line first at a fine speed. Then came Nikodem and afterward, Wondrick. The Austrian, Wondrick, and Demester, of the French team, made the best time. Demester's machine undoubtedly made a higher speed, but the Austrian gained upon him in the long run. Besides, Demester had several accidents to his pneumatics, and even had to change the rear wheel, which eventually disqualified him for the race. The Peugeot wheel, mounted by Guippone, was also among the first. The German and English teams were not as rapid, and, in fact, they did not finish the race at the head of the list. At the end of the fifth round, Wondrick came in ahead; then Demester, and third Guippone. But as Demester was disqualified, for the reason we mentioned, Wondrick took the first place, with Guippone second. The official time of the winner for the net distance of 146 miles was 3 hours, 5 minutes, 15 seconds. Guippone was not far behind him in 3 hours, 35 minutes, 2 seconds. Demester's time, which was second best, was 3 hours, 13 min., 2 sec.; he would have been counted second had he not changed his rear wheel.

As regards speeds for the mile and the kilometer, which were taken at a point on the course between two fixed points, while the racers were passing at full speed, we find both the French and Austrian machines made a remarkable performance. The former, represented by Demester, on his Griffon wheel, were ahead as regards speed pure and simple, seeing that Demester made the kilometer (0.6 mile) in 34 2-5 seconds. This kept up at a constant rate would give about 70 miles an hour. Wondrick's time is somewhat

DEMESTER STANDING BESIDE HIS FRENCH GRIFFON RACER.

less than this, or 37 seconds for the kilometer, but he made the best average speed for the five rounds, or 146 miles, which he covered at the rate of 61 miles an hour.

Thus we find that the motor cycle is continually making progress, and the speed is becoming higher and higher. At the same time these little machines show great qualities of endurance. Next year's international race will be run in Austria, and we may expect an interesting struggle, for France will make every effort to win back the cup, which it has held thus far.

FORTY-HORSE-POWER GASOLINE TRACTOR FOR THE BRITISH WAR OFFICE.*

THE mechanical transport department of the British war office is extensively developing the employment of gasoline-propelled tractors for the most difficult class of work. Such vehicles possess many advantages over other systems of propulsion, the most prominent of which are mobility, compactness, and convenience both in handling and the carriage of the requisite fuel.

The department has recently acquired a powerful tractor propelled by this means, which it is intended to utilize for the roughest work and under the most severe conditions from the Wolseley Motor Company of Birmingham. Through the courtesy of the War Office we are enabled to publish a description of this latest equipment.

In general appearance the vehicle closely resembles the steam type of tractor. The rear driving wheels are of the same description, being of large diameter, heavy construction of steel, with a wide and corrugated tread so as to obtain a ready purchase upon the most treacherous soil. It is built throughout of steel and the power is developed by a four-cylinder Wolseley horizontal gasoline engine developing 40 horse-power on the brake. For the purposes of accessibility to the driver or his assistant from the seat, or when running, the engine is mounted on the top of the frame and has a wide clear platform running round it, on the same level as the footplate. Any part of the motor can thus be reached. The exhaust gases are carried away into the outer air through a funnel of small diameter.

The power is transmitted from the engine to the change-speed gear box by a silent running chain, thence from the gear box to the rear driving wheels by roller chains. The gear box contains three countershafts and the sliding gear system is adopted to give the different speeds, being operated by a cam. There are four forward speeds, the maximum being 8 miles per hour on the level. There is one reverse speed of 5 miles an hour fitted. The differential gear is arranged in line with the third countershaft. An ingenious device has been incorporated whereby it is possible to lock the differential gear. The object of this is that when one driving wheel becomes imbedded in loose soil the vehicle can extricate itself under its own power. By locking the differential gear the road wheels revolve together instead of independently, and thus a grip can be brought to bear by the imbedded wheel.

Adequate braking arrangements are fitted. There are internal brakes fitted to each road wheel and the countershafts are similarly equipped. The whole of the braking arrangements are controlled from the driver's seat. For emergency purposes the rear wheels are also fitted with a powerful winding gear.

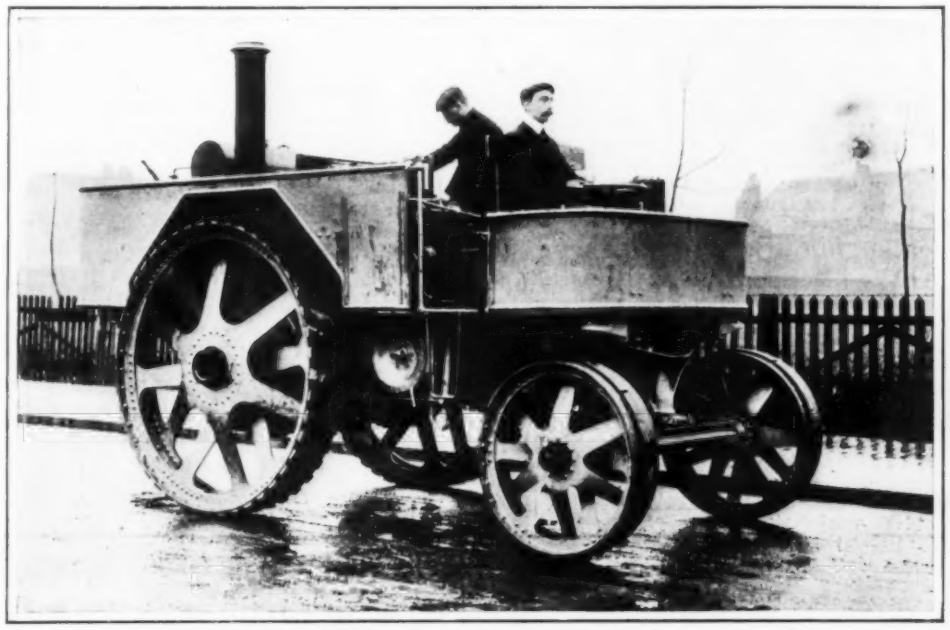
Haulage capacity rather than speed is the object of this tractor. It can haul a load of ten tons over the roughest ground and will haul a heavy field gun together with its two-wheeled carriage under such conditions without any danger of injuring or disturbing the working parts of the weapon, either from shock or other causes. The engine being placed upon the top of the frame gives a clearance from the road of 2 feet, thereby enabling the tractor to be driven through brooks and streams without the mechanism being affected by the water.

The tractor is especially required for the haulage of a traction wagon weighing five tons, and a gun on its carriage weighing another five tons, and this ten-ton load it can haul along the level at a speed of 8 miles an hour, while it will negotiate gradients of 1 to 6 with full load. Although essentially designed for the consumption of gasoline, as this volatile fuel cannot always be procured, especially in out-of-the-way places, petroleum with a flash point of 75 deg. F. can be successfully used.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

SOME PROBLEMS IN STEAM TURBINE DESIGN.

THE value of scientific knowledge and methods in developing inventions has been the subject of so much general discussion that little is left to say except in stating specific instances, which prove the truth of the assertion. The rapid development of apparatus so novel as the steam turbine has only been possible by the use of scientific design, as pointed out by Prof. Louis C. Loewenstein in the Journal of the Franklin Institute recently. He pointed out that we might refer in proof of this assertion to the importance of previously determining the exact dimensions of a rotating wheel whose periphery almost reaches the velocity of a bullet, in order that the existing stress in the material will not at any place exceed the allowable limits. Or, again, how disadvantageous it would be in the case of the horizontally rotating disk wheels that have lately come into use, and whose diameters attain considerable dimensions, to determine, experimentally, after first constructing, how much the disks deflect on account of their own weight, and how much they again straighten out, due to their centrifugal force—the latter a point of great importance, if we consider the scraping of the blades in the narrow clearance. What dangers the designer risks when he attempts the building of steam turbines without having exact knowledge of the phenomena of the so-called critical velocity.



A 40-HORSE-POWER TRACTION ENGINE OF THE BRITISH WAR OFFICE.

Among the important scientific investigations that must be made by the designer of steam turbines, Prof. Loewenstein mentioned the flow of steam through orifices, nozzles, and blade channels; the friction of rotating disks in a steam medium; mass balancing and the theory of the flexible shaft; critical velocity and period of oscillation due to elasticity; the deviation of rotating disks due to the bending of the shaft; the deflection of horizontally rotating disks and the action of centrifugal force upon them.

It is well known if steam, or in general any elastic fluid, flows through a simple orifice from a space of higher into one of lower pressure, the pressure in the orifice will decrease to about one-half the initial pressure, and there will occur in the stream after leaving the orifice strong acoustic vibrations. These vibrations cause a considerable loss of efficiency, and they must be avoided. De Laval has accomplished this by adding to the orifice a conically diverging nozzle in which the steam can continuously expand down to the back pressure. Before the design of the nozzle can be undertaken it is necessary to fully understand the flow of steam in nozzles. Experiments were made to investigate this flow, and Prof. Loewenstein described briefly how they were conducted and the results derived.

An orifice of a nozzle through which the flow of steam was to be investigated was so mounted that a thin measuring tube could be inserted through the center of the opening. One end of this measuring tube was closed and the other end was connected with a pressure gage. In the middle of this tube a hole was drilled at right angles to the axis. By means of a micrometer screw this tube could be moved in one direction or the other, so as to bring the measuring opening in any position of the nozzle axis. Experiments were first made to ascertain how reliable this method would be for the measurement of pressure, for, as can be seen, it is not sufficient to place a measuring opening tangential to the flow of steam, but the position and the condition of the edges of the opening may be responsible for a disturbing effect. These experiments showed, however, that the readings taken in this manner could not materially differ from the true pressure. By now allowing steam to flow through orifices and nozzles of various shapes it was possible to plot a curve of pressure showing the variation of pressures throughout the length of an orifice or nozzle, and even beyond it. Some very interesting and important results were obtained.

The resistance to steam flow was first investigated, and after a great many experiments were made the conclusion was reached that it is allowable to consider the resistance to steam flow in a diverging nozzle as simple tube friction. With nozzles of small divergence and less than 2 inches long, and about ¼-inch minimum diameter, the loss of energy was about 10 per cent, and with nozzles of greater divergence and about 4 inches long, and ⅜-inch minimum diameter, the energy loss was 15 per cent. The decrease of velocity is about half as great.

Through partly closing a valve placed between a nozzle and a condenser it is possible to produce any desired back pressure. In measuring the pressure in various parts of the nozzle, the pressure first follows the line of free expansion and then increases according to the value of the back pressure in more or less sudden leaps. In these extraordinary heavy increases of pressure we find a realization of the theoretically derived "compression shock" of Von Riemann. The steam particles possessed of great velocity strike against a slower moving steam mass and are therefore compressed to a higher degree. Such compression shocks will always occur when the nozzle has a greater length, that is, a larger cross-section divergence, than the initial and the final pressures demand.

Other experiments were made on the flow of steam through orifices. These experiments gave the desired explanation of the phenomena of flow from orifices.

Messrs. Mack and Emden proved by means of photographs the presence of regular successive light and dark lines in a steam flowing from an orifice, which cannot be said to be anything else but acoustic waves; but as to the value of the existing pressures in this stream we were totally in the dark. Emden assumed that at places of compression the same condition exists as in the orifices, but he further said in contradiction to himself that there exists the same pressure at every place in the steam as exists in the surrounding atmosphere, and claims that there is a change of density. According to this, for instance, for air, places of smallest velocity, that is smallest energy, must coincide with places of smallest temperature, that is, smallest potential energy, which, Prof. Loewenstein says, is obviously impossible. By his calculation he further believed to have proved that the difference between the initial and the orifice pressures can only be used to produce the additional velocity of flow; the remainder of the available work is transformed into acoustic energy. The experiments lately made by Prof. Stodola contradict these opinions; they prove that the steam first expands to the existing pressure before the orifice, that therefore the first rush (as in the case with suddenly releasing a compressed spring) too much potential energy is changed into kinetic energy. Only this excess changes into acoustic vibrations and is rechanged into heat at the rim of the stream by friction and eddy currents. The oscillations occur in the axial direction as well as in the radial. The stream flows at the pressure of the orifice into a region of much smaller pressure, and begins to expand in a radial direction. The resulting drop of pressure accelerates the particles also in the axial direction. Steam flowing from a diverging nozzle shows the same phenomena as from a simple orifice. With varying back pressure it was found that the steam on leaving the nozzle gave very regular acoustic vibrations, but it was possible to so fix the back pressure that every trace of a vibration disappeared.

From these experiments it is finally determined that the steam in a nozzle expands nearly adiabatically independent of the back pressure. If the steam flows into a place in which a back pressure exists exactly equal to the final pressure of expansion then the pressure in the stream is not changed at all. If the pressure is lower, acoustic vibrations occur, as with a simple orifice; if the back pressure is too high, a steam shock occurs with more or less drawn-out oscillations. By entirely filling out the cross-section of a diverging nozzle, a vibration is made difficult, if not entirely impossible. Prof. Loewenstein believes we can hardly go wrong if we say that the drawn-out vibrations occurring in a simple orifice are caused primarily by the sudden difference of pressures at the stream's rim and the surrounding atmosphere, which the stream quickly spreads. There is, therefore, the possible assumption that when vibrations still occur in the interior of the nozzle, the stream has detached itself at such places from the wall.

If the nozzle is constructed according to the formula of Zeuner, the final pressure will be greater than the prescribed back pressure, because friction transposes the kinetic energy into heat, and the expansion line will rise above the adiabatic. A nozzle calculated, therefore, according to Zeuner would actually be somewhat too long. This fact was soon recognized. To correct this Rateau, and after him Delaporte, proved by experiments that the pressure of a stream on blades or suitable plates decreased very little if the nozzles were made shorter—that is, the stream is allowed to flow out at a slight over-pressure—and recommended that this be done. It remained for Stodola to prove by his experiments just mentioned that violent acoustic vibrations would then take place in the stream, and that these must be avoided. It is important to make the nozzle dimensions suitable to the assumed back pressure. Before correct nozzle dimensions can be determined we must know from experiments the probable steam friction loss in the nozzle and then the design of the nozzle is easily accomplished.

In conclusion, Prof. Loewenstein pointed out that in the steam turbine we are confronted with an entirely new series of phenomena. The knowledge of steam accumulated by familiarity with the reciprocating engine is of little use in designing this newest yet oldest of prime movers. Nor can the cut-and-dry methods that have brought the reciprocating engine to its present stage of excellence be employed in the steam turbine. Modern commercial conditions are such that design must be based on ascertaining physical laws. This rapid advance has necessitated the re-investigation of steam from the point of view of velocity instead of pressure, of kinetic energy instead of potential, and the friction of rapidly moving bodies against a vapor instead of a lubricated surface, of the balancing of parts so that they shall revolve about their center of gravity, and of numerous other questions which are but beginning to make themselves felt. The available data are few, and practically all of the information is scattered through the pages of German and French scientific periodicals and a few books.—Eng. Record.

ELECTRIC POWER FROM BLAST FURNACES.*

By P. Eyermann.

ADVANTAGES OF ENGINES DRIVEN BY BLAST FURNACE GAS.

Gas engines driven by blast furnace gas have now been in successful operation in Germany more than ten years. In the very first stages of this development many prominent engineers reached the opinion that ultimately this use of the blast furnace gas would result in the erection of auxiliary plants to take advantage of the power thus cheaply generated. There is no doubt that large cities such as New York, with the enormous amount of electric power they require, would offer opportunities for profit from the erection of such works. The writer has made a calculation for the purpose of demonstrating in detail why such a proposition has a good basis. Objections may of course be raised on the basis of experience obtained with existing furnaces of the old-fashioned type. The smoke from coal fires in operating boilers and the enormous quantities of dust escaping from blast furnace stacks, stoves, and chimneys may afford ground for serious objections. But these troubles are overcome with gas engines, and a modern blast furnace plant can be made to keep its surroundings thoroughly clean. Even if coal is supplied directly to a plant and not coke, there is no dangerous smoke or gas escaping from up-to-date coke ovens.

In cities with convenient harbor equipments like New York or Philadelphia a big coke-oven plant, blast furnaces, or a steel plant may become a desirable industry in the future, since it would be coupled with less dust and smoke troubles than any large city power and light plant, skyscraper building, or illuminating gas works.

The following improvements made in the last ten years constitute the most important reasons for a change in the iron industrial situation: No waste in coal, no waste in coke, no waste in water, no dust nuisance from iron ores, no nuisance from smoke, no escaping steam, no steam engine, no smokestack at all, no boiler explosion danger, no boilers.

A FURNACE PLANT CONSIDERED AS A GAS PRODUCER.

The main point in regard to the construction as well as concerning the management of such a big gas producer as a blast furnace plant may be considered as follows: The complete plant may be based to-day on selling electricity and obtaining as main by-products coke (with its auxiliary by-products, sulphate of ammonia, benzol, sal-ammoniac, tar, and naphtha), pig iron (with its auxiliary by-products, slag cement, bricks, and heating gas), and steel, if desired. As the installation of gas engines instead of steam motors is the most important matter, therefore the apparatus for gas manufacturing, such as the coke ovens and blast furnaces, must be constructed with reference to the most favorable conditions for the operation of the gas engines. The coke ovens as well as the blast furnaces should be provided with a charging mechanism which works as continuously as possible, because the thermal efficiency of the gas engine depends upon the regular and continuously uniform quality of the gas. The financial efficiency of the plant depends also upon the gas engine, as the latter produces the main product—namely, electricity.

There is also no doubt that a continuous charging of the blast furnace assures a better run and a better gas. Thus the main product is also obtained very regularly and the by-products can be drawn continuously in lieu of intermittently, as now. The pigs may be made by continuous casting on an improved pig iron casting machine, and the same can be said for the slag. If pigs of only 40 pounds each are cast (and this is convenient for cupolas) and the blast furnace should be of 576 tons daily capacity, then 20 such pigs are cast per minute, or one for each three seconds of casting time, which is just right for the machine.

NEW YORK AS A FURNACE LOCATION.

A blast furnace plant in New York would be based on a supply of iron ores shipped from the lake harbors to the plant by water from Buffalo. Other sources would be Canada, Spain, etc., by the Atlantic Ocean. The fuel supply may be based on direct coke contracts or on shipments of coal from Pennsylvania, Virginia, etc. The latter method may be preferred, as the power from the coke oven gas is secured and the other by-products are made right in the market. Thus, starting with the coke ovens, an approximate calculation is as follows:

Of coal, 11,000 tons yield 10,000 tons of dry coal or are converted into 7,850 tons of coke; the balance on an average consists of 120 tons of ash, 110 tons of sulphate of ammonia, 100 tons of tar, 30 tons of pitch, 60 tons of benzol, 5 tons of naphtha and 2 tons of sal-ammoniac, or about 8,250 tons of products out of 10,000 tons of dry coal. There is also produced 1,600 tons of coke oven gas from which it is desirable to earn profits. If such a complete plant belonged to the municipality the city would have its own required electricity free of cost.

Practice has proved that 1 ton of coal is equivalent to 10,000 cubic feet of such gas, or even more. The heating value is nearly the same as that of city gas, averaging, say, 600 British thermal units per cubic foot. Many gas engines will yield 1 horse-power for 10,000 British thermal units, but, conservatively, 12,000 British thermal units may be taken in this calculation, making each horse-power require only 20 cubic feet of coke oven gas per horse-power per hour. Of the gas made 50 per cent is used for heating the ovens, and if a further loss is allowed of 10 per cent of the gas for uncontrollable leakage, or for engines running under less favorable conditions, then 4,000 cubic feet of gas is available for power, or 200 horse-power for each ton of coal.

The same result may be checked in the following way: 1,600 tons of coke oven gas will yield approximately 112,000,000 cubic feet, as 1 ton of gas is equivalent to 70,000 cubic feet at normal temperature. Deducting 10 per cent for loss and 50 per cent for heating purposes leaves 44,800,000 cubic feet, or 2,240,000 horse-power. Dividing this by 11,000 tons, the quantity of coal, we reach an equivalent of 230 horse-power per ton of coal, or, referred to the coke, approximately, taking 216 horse-power as an average of the above two results per ton of coke, 200 horse-power, which is usually lost to-day.

DETAILS OF OPERATING SUCH A PLANT.

One ton of pig iron requires an average of 1 ton of coke and 2 tons of iron ore. With one furnace of 576 tons daily output especially designed as a gas producer for the subsequent generation of electricity through gas engines the calculation works out as follows:

With the object of obtaining somewhat richer blast furnace gas than may be obtained by using coke alone some coal may be charged into the furnace with the coke. It may be preferable also under certain conditions to mix the furnace gas with the gas from the coke ovens in order to secure a more uniform gas. For each ton of pig iron there would be obtained an average of 150,000 cubic feet of gas having a heating value of at least 100 British thermal units per cubic foot. As it may be also possible in the future to heat the required blast with the waste heat of the liquid cinder, thus doing away with the stoves, it is even conceivable to figure that for each ton of pig iron may be produced the following power: The gas has $150{,}000 \times 100 = 15{,}000{,}000$ British thermal units, and the gas engine requires 12,000 British thermal units per horse-power, thus making 1 ton of iron equivalent to 1,250 horse-power in a 576-ton plant, or 30,000 horse-power per hour.

At present, however, we must consider the following: From this $150{,}000 \times 24 = 3{,}600{,}000$ cubic feet of blast furnace gas 25 per cent is to be deducted for heating the stoves. In earlier days the amount was higher, but in a modern plant, equipped with improved cleaning apparatus, not more will be required. Therefore 900,000 cubic feet are set aside for heating gas for the blast.

For supplying air to the coke in the blast furnace by means of the blowing engines the latter are built on an average for, say, 80 to 100 cubic feet of air per pound of coke charged. For 24 tons of coke required per hour under these conditions $2{,}000 \times 24 \times 100 = 4{,}800{,}000$ cubic feet of air are required per hour. With a pressure of 20 to 25 pounds on an average, each 100 cubic feet per minute may require horse-power up to 5 per hour, or $4{,}800{,}000 \div 60 = 80{,}000$ cubic feet per minute, requiring an engine of 3,200 to 4,000 horse-power. Each horse-power of that engine would require 12,000 British thermal units, or 100 cubic feet, of blast furnace gas which would result in a further deduction of 400,000 cubic feet of gas for the blowing engines.

The uncontrollable leakages and losses in an up-to-date plant should not be more than 5 per cent or 180,000 cubic feet.

Mechanically operated cleaning plants have given the best results and are using from 0.4 to 0.7 horse-power for 1,000 cubic feet. If all the gas is cleaned this would take $3{,}600 \times 0.7 = 2{,}520$ horse-power, or another loss of 252,000 cubic feet of gas per hour, for cleaning purposes.

For auxiliary machinery, such as ore and coke handling appliances, electric light, power transmission, compressed air and water pumps, elevators and hoists, pig iron casting machines, etc., there would be required per ton of pig iron per day nearly 2 horse-power per hour, or another loss of $576 \times 2 = 1{,}152$ horse-power, or 115,200 cubic feet, of gas per hour.

Without further considering in this connection the possibility of heating open hearth furnaces, etc., with blast furnace gas, the power expressed in electricity which is daily obtainable is as follows:

	Cubic feet.	Cubic feet.
Blast furnace gas		3,600,000
Less:		
Blast heating gas	900,000	
Blowing engine gas	400,000	
Furnace loss	180,000	
Cleaning gas	252,000	
Power gas (auxiliaries)	115,200	
		1,847,200
Remaining for further utilization		1,752,800

The gas thus remaining when converted into electric power by gas engines gives 17,528 horse-power on the brake, and, allowing 10 per cent loss for efficiency in the electric generators and transformers, $17{,}528 - 1{,}752 = 15{,}776$ electrical horse-power, equivalent to approximately 11,760 kilowatts.

It is now only a few years (1896-1897) since pig iron was placed on the New York market at $10.50 to $12 a ton. It is to be hoped that such times will not come again, but they should be remembered in considering the basic costs. The price of coke in large quantities delivered in the bins may be placed at $3.50 per net ton. Iron ore under various conditions may be had at $2.50 per ton; adding for lime, repairs, labor, etc., and maintenance another $3.50, brings the cost of pig iron up to $12 per ton, assuming that the plant is valueless after ten years. The cost per kilowatt is obtained on the basis of 24 tons of pig iron per hour, producing 11,760 kilowatts. One ton of pig iron is thus equal to 490 kilowatts, and as each ton costs $12, 1 kilowatt costs 2½ cents to produce.

Theoretically it may be said that pig iron is a by-product of the new improved gas producer, fired with coke and charged with iron ore as a flux for the ash and clinkers. The latter are melted down, however, thus avoiding the stoking, and characterizing the blast furnace as the best gas producer of larger size. The

* Iron Age.

connection of a steel plant is desirable, because in it the coke oven gas may be used either pure or mixed with the blast furnace gas for heating the various melting and heating furnaces. The boiler is then entirely avoided, as all rolling-mill engines run on gas, all auxiliary machines with electricity, and no other coal is supplied than may be required for the manufacturing of the coke for the blast furnace. This would constitute an electric plant using only plain coking coal and iron ore for power.

[Concluded from SUPPLEMENT No. 1545, page 24759.]

PRECIOUS METALS RECOVERED BY CYANIDE PROCESSES.*

By CHARLES E. MUNROE, Ph.D.

The methods used in the Witwatersrand have been described recently by John Hays Hammond,† as follows:

"The following description applies to the treatment of ores in the pyritic zones. Ores from the upper (oxidized) horizons of the reefs, which constitute but a small percentage of the ores treated, require a slight modification of the process.

"The ground near the mines is level, and does not permit transportation by gravity; consequently the ore must be first elevated into the ore bins at the mill, and the tailings leaving the mill must be elevated for treatment by the cyanide process. This is done either by tailing pumps, or, preferably, by tailing wheels. These are from 40 to 50 feet in diameter, and discharge the tailings into a launder, which, with a grade of about 3.5 per cent, carries them to the cyanide works. The auriferous pyrites are, to a large extent, taken out as concentrates by means of Spitzlutten (hydraulic classifier). About 10 per cent of the mill pulp recovered in this way consists of pyrites with coarse sand, a concentration of 10 to 1 being obtained. These concentrates are taken to tanks for separate treatment. From two to three weeks of treatment is required in order to obtain from this material a recovery of from 90 to 95 per cent of the gold it contains. A solution of about 0.25 to 0.3 per cent of cyanide of potassium is used. After passing over the Spitzlutten the tailings are run to Spitzkasten (pointed boxes), where the heavier sands are allowed to settle, while the lighter material (slimes) overflows, and is carried to the slime works for special treatment. The sands which settle in the Spitzkasten, representing about 70 per cent of the battery pulp, are continuously discharged by pipes leading from the bottom of the box, and are delivered by a hose or by an automatic revolving distributor to settling tanks, into which they are so fed as to be as thoroughly mixed as possible. This separation of the sands from the slimes has to be carefully made, so as to remove all clayey substances, the presence of which would otherwise prevent rapid percolation of the solution and the free access of atmospheric oxygen, which is essential to the solution of gold by cyanide.

"Most of the modern plants have a system of double treatment, the tailings being settled in the settling tanks, when they are treated, after being allowed to drain, with a weak solution of cyanide of potassium. This addition of the cyanide of potassium is made rather for the purpose of saturating the sands with the solution than for thorough leaching, which would be difficult on account of the packing of the sands as they are settled, rendering percolation difficult. After the solution has been drained off, the sands from the settling tanks are discharged into the leaching tanks, placed immediately below the settling tanks, from which they are filled from discharge doors on the bottom of the latter. For a 200-stamp plant sixteen steel settling and sixteen steel leaching tanks are usually employed. From three to four settling and leaching tanks are used for the treatment of the Spitzlutten concentrates above described. The settling tanks are usually 40 feet in diameter and 9 feet high. The leaching tanks have the same diameter, but usually a foot less height. The capacity of these tanks is about 400 tons of pulp each.

"In the leaching tanks the pulp is subjected to three treatments with cyanide of potassium. Where the MacArthur-Forrest process is used, the strong solution contains 0.25 per cent, the medium solution 0.2 per cent, and the weak solution 0.10 per cent of KCy. In the Siemens-Halske process the solutions are weaker, namely, the strong solution, 0.10; medium, 0.02; and weak, 0.01 per cent of KCy.

"The treatment requires from four to seven days. From 130 to 150 tons of solution are usually employed for 100 tons of sand. After being allowed to drain, the sands are discharged through bottom discharge doors into trucks, in which they are removed to residues or tailings heaps. Here, again, elevation is necessary, on account of the flatness of the country, and is usually effected by the endless rope system. These tailings heaps are conspicuous throughout the mining district. By reason of the heavy winds prevailing at certain seasons of the year, they are becoming a great nuisance, and the question of their future disposition is one of the problems for the mining engineer.

"The cyanide solution, after being drawn off from the leaching tanks, is taken to the precipitation boxes. The gold from the strong solution is precipitated in one set and that from the weak solution in another set of boxes. Precipitation is effected by either the MacArthur-Forrest or the Siemens-Halske process.

"The MacArthur-Forrest Process.—In this process the gold is precipitated by zinc, the solution passing upward through a succession of compartments, in which are placed zinc shavings or filings, resting on a movable tray of coarse screening. About twenty precipitation boxes, 20 feet by 3 feet by 3 feet 9 inches in size, are used. The gold-bearing solution is brought into close contact with the zinc, causing the deposition of the gold, partly as a metallic coating on the zinc and partly as gold slimes, which sink to the bottom of the box. As the zinc is gradually dissolved by cyanide more is added.

"Once or twice a month the boxes are emptied, and the gold slimes are treated with dilute sulphuric acid, then dried and melted in crucibles. The dried slimes contain about 15 to 20 per cent of gold, and after fluxing with borax and soda an ingot of 0.750 to 0.800 fineness in gold and 0.100 in silver is obtained. The slag, carrying from 5 to 50 ounces of gold per ton, is usually sold to smelters.

"This precipitation process yields satisfactory results only with solutions containing more than 0.1 per cent of cyanide, the weaker solutions not being acted upon by zinc. An improvement of the method is the addition of lead to the zinc, whereby the combination of the two metals forms a galvanic couple, which also reacts with weaker solutions, such as are employed, for example, in the treatment of slimes.

"The Siemens-Halske Process.—In this process the solution flows through compartments very similar to the zinc boxes above described, but the zinc shavings are here replaced with lead strips (0.1 pound per square foot) or shavings hung between iron plates placed vertically and longitudinally in the box, about 4 inches apart. The lead strips are connected with the negative, and the iron plates with the positive pole of a dynamo, and the solution is thus electrolytically decomposed, the gold being plated on the lead cathode. The iron plates are wrapped in canvas to prevent short-circuiting. The current employed is from 2 to 3 volts, giving a current density of about 0.06 ampere per square foot of cathode. Once a month the lead sheets are removed and replaced, and the gold-coated lead is melted and cupeled, yielding a bullion of 0.880 fine in gold and 0.100 in silver. The litharge is sold to smelters. The solutions passing through the treatment boxes are collected in tanks, and are made up to a proper strength by adding the necessary KCy.

"The cost of the Siemens-Halske process is slightly greater than that of zinc precipitation, and the percentage of extraction is about the same. But the Siemens-Halske process may be applied to any solution, weak or strong."

Scope.—From the description of its mode of operation it is evident that the "straight cyanide process" is readily applicable to free milling ores which are free from mineral substances that would foul the solution or consume the cyanogen salt, and the gold in which is finely divided and so exposed that the cyanide solution may come in intimate contact with it. In old tailings which have been exposed for years to the action of the weather, whereby the sulphurets have been oxidized and the acids and salts formed, dissolved and washed away, there has been found much material ready at hand for immediate treatment in the simplest manner. The problem is comparatively simple, also, in the case of siliceous gold-bearing deposits free from sulphurets, but the ore must be crushed, and in many instances it is more economical to concentrate it than to expose the entire mass to the action of the cyanide solution. Moreover, even in the case of neutral and otherwise suit[illegible] the fine particles of metallic gold may be so enveloped in an impermeable covering—such as iron or aluminium hydroxide—as to necessitate a preliminary treatment, such as roasting, to rupture the envelope. An example of this kind is found in the ores of the Republic gold mine, Washington, described by T. M. Chatard and Cabell Whitehead.* When coarse gold is mingled with the fine, it is usually more economical to separate the coarse gold by amalgamation than to await the slow-acting process of solution. With tailings in which the sulphurets are but partly decomposed and which still contain ferrous and ferric salts and sulphuric acid, cyaniding may be preceded by washing and neutralization.

The treatment of refractory ores is determined, in each case, by the chemical and physical characteristics of the ore under consideration. Hence, we find that cyaniding may be combined not only with crushing, roasting, concentration, and amalgamation, but also with smelting and chlorination. In some instances it is most advantageous to separate the ore into fractions, each of which is subjected to a different treatment. In fact, it is essential to success that the ore should be thoroughly examined by a competent metallurgical chemist before any investment in a plant for treatment by chemical processes is made, and also that the cyaniding process should be under chemical supervision, in order that, by assays of the ore and tailings and by analyses of the ore and the cyanide solutions as they enter and issue from the zinc boxes, and of the solvent during preparation and regeneration, a complete check may be made upon the operation in each of its stages.

Working Costs.—It is obvious that the cost of the cyanide process will vary at the different plants, according to the variations in the chemical composition and physical structure of the ore treated, in the condition of the ore at the time of treatment—that is, whether it be in the form of sand or slimes—in the character of the process and the apparatus used; in the location of the mill with regard to the supply of ore or tailings used; and the source of power, water, materials, and labor. According to H. M. Chance,* in the Black Hills, S. Dak., the cost of smelting siliceous ores was between $4.75 and $5.75 per ton; the cost of chlorination, from $3.50 to $4.50 per ton; and the cost of the cyanide treatment, possibly from $3 to $3.75 per ton. From the Report of the Director of the Mint, for the calendar year 1901,† it appears that in that year there were 11 cyanide plants in active operation in South Dakota, having a united capacity of over 1,500 tons daily, and that some of these mills claim to be able to treat ore at a cost not exceeding 80 cents per ton, though the average cost is probably nearer $1.50 per ton. Julian and Smart‡ give 21 different detailed accounts of costs at mines in Australia, Africa, and the United States, the results ranging from 2s. 1.23d. per ton by the Siemens process, in South Africa, to 17s. 1.02d. per ton by the Diehl process, in Western Australia.

Effect on the World's Supply of the Precious Metals.—The data collected at this census deal only with the output of the United States for 1902. There are no collected data to afford a comparison of the condition of this industry in that year with the condition during any previous period since its introduction into this country, in 1891. But the consensus of evidence, as presented in current literature, indicates that the industry has been constantly growing, that new plants are going up each year, and that established ones are increasing their capacity. This is true not only of the United States, but also of Africa, Australia, New Zealand, Mexico, and the other gold-producing countries; from each are coming increased supplies of the precious metals extracted from low-grade ores and tailings.

CALENDAR OF EVENTS AND DISCOVERIES RELATIVE TO THE PRECIOUS METALS.

1530-1540.	Pillage of Peru.
1547-1548.	Discovery of Guanajuato silver mines in Mexico.
1577.	Discovery of gold in Brazil.
1670.	Discovery of placers of Garazua.
1680.	Discovery of placers of Minas-Geraes.
1704-1728.	Silver mines opened in Russia.
1743.	Discovery of gold in the Ural.
1848.	Discovery of placers in California.
1848.	Introduction of Plattner's chlorination process at Reichenstein in Silesia.
1851.	Discovery of placers in Australia.
1853.	Introduction of hydraulic mining in California.
1853.	Maximum annual production of gold in California, amounting to $65,000,000 for the year.
1858.	Introduction of chlorination process at Grass Valley, California.
1866.	Invention of dynamite.
1886.	Opening of the "banket" reef of the Rand, South Africa.
1889.	Development of Manké's method of bessemerizing copper mattes, and the successful refining of this impure copper by electricity.
1890.	Introduction of the cyanide process in the Rand, South Africa.
1897.	Discovery of placers in the Yukon.

Apart from the phenomenal annual increase in the production of gold during the period from 1841 to 1855, which includes the discoveries of the rich placers of California and Australia, the increase in the world's production during the last decade of the nineteenth century was unprecedented. It was most marked during the period from 1891 to 1895, following the opening of the "banket" reef of the Rand and the introduction of the cyanide processes, but it was continuous throughout the decade, except during the period of the Boer war, and the output of gold in 1902 exceeded that of any other year of our record except 1899. It is true that the use of the cyanide process is only one of several causes contributing to this result, but that it is an important one is indicated by the fact that the returns for this census show that the amount of gold recovered by the use of the cyanide process in the United States in 1902 exceeded that won throughout the whole world by all existing means during any year of our record up to 1661, and probably up to 1701.

COUNTERFEIT RELICS.

AN article in a recent number of the Birmingham (England) Mail states that a factory in that city is turning out weekly about 1,200 flint-lock muskets, and that a large number of this antiquated firearm are also made at Liege, Belgium. These guns are sent to Central and East Africa for use by the natives, to whom the possession of modern firearms is denied by statute. Directing attention to this industry, Consul Halstead says:

It is known in the trade that many of these newly made weapons fall into the hands of travelers who regard them in the light of a "find," and a story is told of a Birmingham manufacturer having received a letter from a dealer asking him to procure some old flint locks, for which the dealer had several customers, when the manufacturer wrote that he could not supply old muskets, but was prepared to make him any number of new ones required. These were, of course, given the appearance of age. The demand for old weapons is so great, especially in the American season, that the genuine articles would go but a little way to satisfy it.

* Census Bulletin.

† Transactions of the American Institute of Mining Engineers, Vol. XXXI., pages 817 to 854, 1902.

* Transactions of the American Institute of Mining Engineers, Vol. XXX., pages 419 to 423.

* Transactions of the American Institute of Mining Engineers, Vol. XXX., pages 278 to 282.

† Production of the Precious Metals during 1901, page 201, 1902.

‡ Cyaniding Gold and Silver Ores, 1904, pages 372 to 381.

[Concluded from Supplement No. 1545, page 24763.]

THE CONSTRUCTION OF A SILVERED GLASS TELESCOPE, FIFTEEN AND A HALF INCHES IN APERTURE, AND ITS USE IN CELESTIAL PHOTOGRAPHY.—IV.

By Henry Draper, M.D., Professor of Natural Science in the University of New York.*

§4. The Observatory.

This section is divided into: a, The Building; b, The Dome; and c, The Observer's Chair.

a. The Building.

The observatory is on the top of a hill, 225 feet above low-water mark, and is in latitude 40 deg. 59 min. 25 sec. north, and longitude 73 deg. 52 min. 25 sec. west from Greenwich, according to the determinations of the Coast Survey. It is near the village of Hastings-upon-Hudson, and is about twenty miles north of the city of New York. The surrounding country on the banks of the North River is occupied by country seats, on the slopes and summits of ridges of low hills, and no offensive manufactories vitiate the atmosphere with smoke. Our grounds are sufficiently extensive to exclude the near passages of vehicles, and to avoid tremor and other annoyances.

An uninterrupted horizon is commanded in every direction, except where trees near the dwelling house cut off a few degrees toward the southwest. The advantages of the location are very great, and often when the valleys round are filled with foggy exhalations, there is a clear sky over the observatory, the mist flowing down like a great stream, and losing itself in the chasm through which the Hudson here passes.

The foundation and lower story of the building are excavated out of the solid granite, which appears at the edge of the hill. This arrangement was intended to keep the lower story cool, and avoid, in the case of the metal reflector, sudden changes of temperature. The eastern side of the lower story, however, projects over the brow of the hill, and is therefore freely exposed to the air, furnishing, when desired, both access and thorough ventilation through the door. The second story or superstructure is of wood, lined inside with boards like the story below. They serve to inclose in both cases a non-conducting sheet of air.

The inside dimensions of both stories taken together

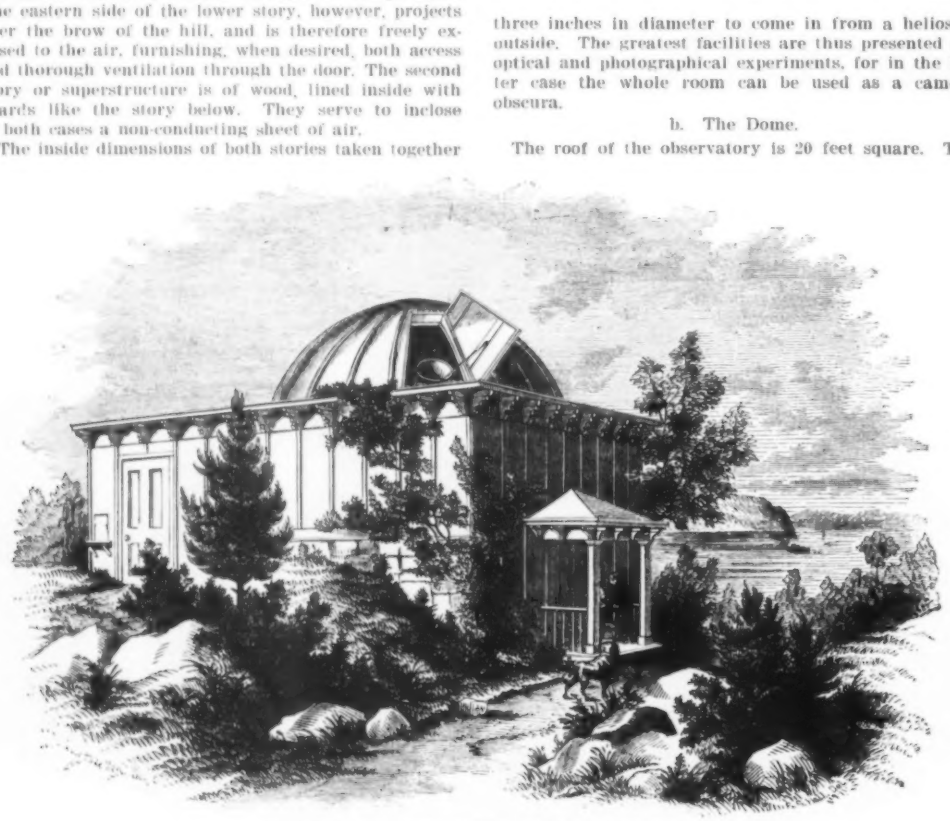


Fig. 37.—DR. DRAPER'S OBSERVATORY.

are 17½ feet square, and 22 feet high, to the apex of the dome. This space is unnecessarily large for the telescope, which only requires a cylinder 13 feet in diameter and 13 feet high. A general idea of the internal arrangement is gained from Fig. 28. In Fig. 38, *a a* is the floor of the gallery, *b b' b''* the circular aperture in which the telescope *c c'* turns. The staircase is indicated by *d*. The enlarger, 86, rests on the shelf *e*, the heliostat being outside at *f*. The door going into the photographic room is at *g*, *h h'* are tables, *i* the water tank, *k* the tap and sink, *l* the stove, *m* a heliostat shelf, *n* the door, *o* the window.

The building is kept ventilated by opening the door in the lower part, and the dome shutter, seen in Fig. 37, for some time before using the instrument. On a summer day the upper parts, and especially those close under the dome, become without this precaution very hot, and this occurred even before the tin roof was painted. Bright tinplate seems not to be able to reflect by any means all the heat that falls upon it, but will become so warm in July that rosin will melt on it, and insects which have alighted in a few moments dry up, and soon become pulverizable. A knowledge of these facts led to the abandonment of wooden sheathing under the tin, for without it when night comes on the accumulated heat radiates away rapidly, and ceases to cause aerial currents near the telescope.

The interior of the building is painted and wainscoted, and the roof is ornamented partly in blue and oak, and partly with panels of tulip-tree wood.

There are only two windows, and they are near the southern angles of the roof. While they admit sunshine on some occasions, they can on others be closed, and the interior be reduced to darkness. In the southeast corner a small opening *e* may allow a solar beam

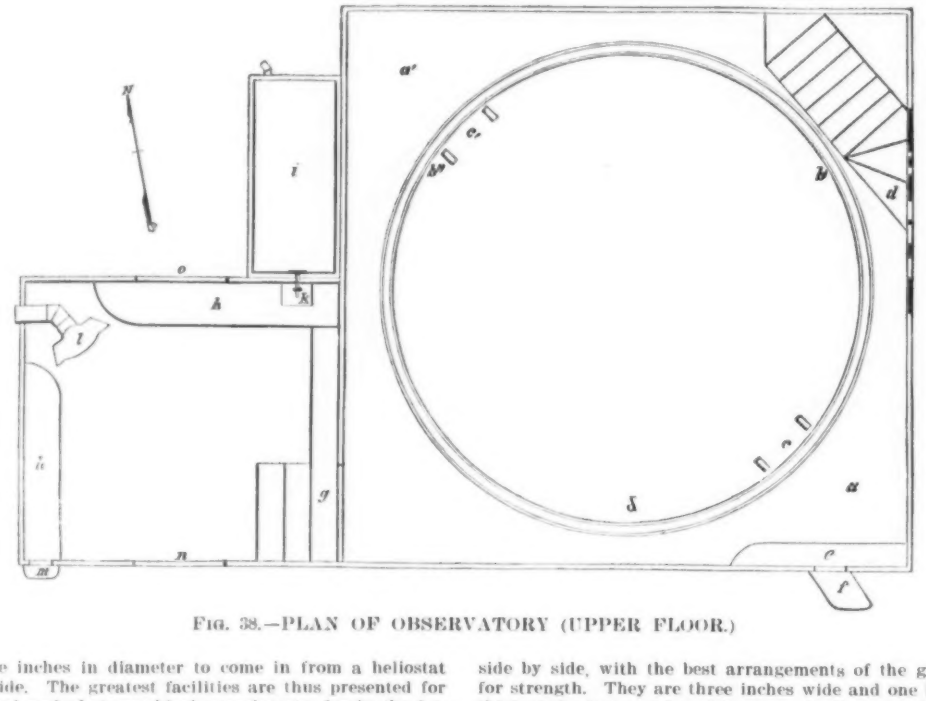


Fig. 38.—PLAN OF OBSERVATORY (UPPER FLOOR.)

three inches in diameter to come in from a heliostat outside. The greatest facilities are thus presented for optical and photographical experiments, for in the latter case the whole room can be used as a camera obscura.

b. The Dome.

The roof of the observatory is 20 feet square. The angles are filled in solid, and a circular space 15 feet in diameter is left to be covered by the revolving dome. Although such a construction is architecturally weak and liable to lose its level, yet the great advantages of having the building below square, and the usefulness of the corners, determined its adoption, the disadvantages being overcome by a very light dome.

The dome is 16 feet in outside diameter, and rises to a height of 5 feet above its base. It is, therefore, much flatter than usual, in fact, might have been absolutely flat, with this method of mounting. It would then have been liable, however, to be crushed in by the deep winter snows.

It consists of thirty-two ribs, arcs of a circle, uniting at a common center above. Each one is formed of two pieces of thin whitewood, *b*, Fig. 39, fastened side by side, with the best arrangements of the grain for strength. They are three inches wide and one inch thick at the lower end, and taper gradually to 2½ by 1.

Over these ribs tinplate is laid in triangular strips or gores, about 18 inches wide at the base, and 10 feet long. Where the adjacent triangles of tin *a a'* meet, they are not soldered, but are bent together. This allows a certain amount of contraction and expansion, and is water-proof. It strengthens the roof so much, that if the ribs below were taken away, this corrugated though thin dome would probably sustain itself. The

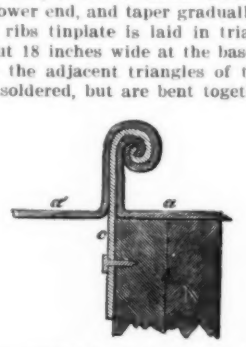


Fig. 39.—JOINTS IN TIN OF DOME.

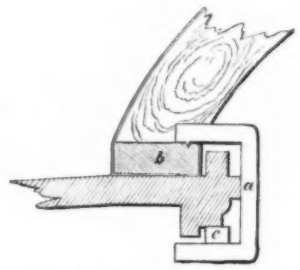


Fig. 41.—A DOME CLAMP.

tin is fastened to the dome ribs *b* by extra pieces *c* inserted in the joint and doubled with the other parts, while below they are nailed to the ribs. In the figure the tin is represented very much thicker than it is in reality.

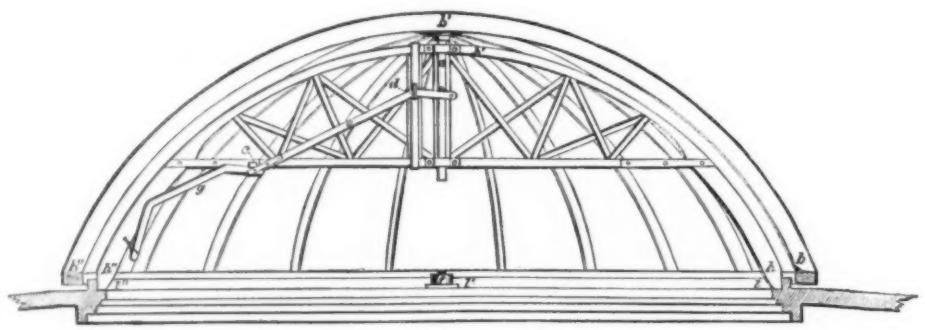


Fig. 40.—THE DOME ARCH.

This dome, although it has 250 square feet of surface, only weighs 250 pounds. That at the Cambridge (Massachusetts) Observatory, 29½ feet in diameter, weighs 28,000 pounds.

The slit or opening is much shorter than usual, only extending half way from the base toward the summit.

* Reprinted from Smithsonian Contributions to Knowledge, Vol. xxxiv.

It is in reality an inclined window, 2½ feet wide at the bottom, 1½ wide at the top, and 4 feet long. It is closed by a single shutter, as seen in Fig. 37, and this when opened is sustained in position by an iron rod furnished with a hinge at one end and a hook at the other.

The principal peculiarity of the dome, the means by which it is rotated, remains to be described. Usually

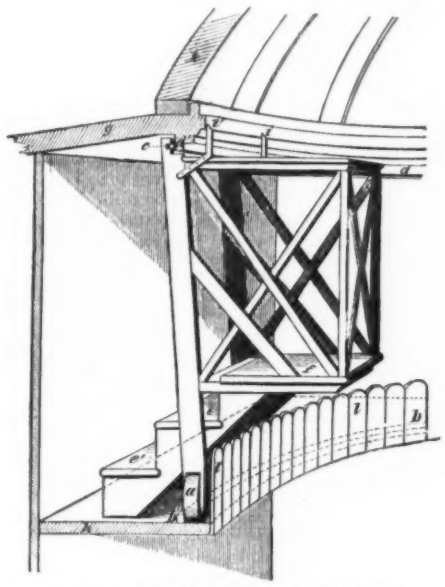


FIG. 42.—THE OBSERVER'S CHAIR.

in such structures rollers or cannon balls are placed at intervals under the edge, and by means of rack work, a motion of revolution is slowly accomplished. Here, on the contrary, the whole dome *b b' b''* (Fig. 40) is supported on an arch *h h' h''*, carrying an axis *a* at its center, around which a slight direct force, a pull with a single finger, will cause movement, and by a sudden push even a quarter of an entire revolution may be accomplished. It is desirable, however, to let it rest on the edge *b b''*, when not in use. At *c* there is an iron catch on the arch, by which the lever *e*, that raises the dome, is held down. The fulcrum is at *d*. The lever is hinged near *c*, so that when by being depressed it should have come in the way of the telescope below, the lower half *g* can be pushed up, the part from *c* toward *d* still holding the dome supported.

The arch can be set across the observatory in any direction, north and south, east and west, or at any intermediate position, because the abutments where the ends rest are formed by a ring *l l' l''*, fastened round the circular aperture, through the stationary part of the roof.

When the telescope is not in use, and the dome is let down, so that there is no longer an interval of a quarter of an inch between it and the rest of the roof, it is confined inside by four clamps and wedges. Otherwise, owing to its lightness, it would be liable to be blown away. These clamps, *a*, Fig. 41, are three sides of a square, made of iron one inch square. They catch above by a point in the wooden basis-circle of the dome *b*, and below are tightened by the wedge *c*.

When the dome is raised it is prevented from moving laterally and sliding off by three rollers, one of which is seen at *f*, Fig. 40. These catch against its inner edge, and only allow slight play. At first it was thought necessary to have a subsidiary half arch at right angles to the other to hold it up, but that is now removed.

All the parts work very satisfactorily, and owing to the care taken to get the roof-circle and basis-circle

FIG. 43.—PLATE CARRIER.

FIG. 44.—PIPETTE BOTTLE.

flat and level, no leakage takes place at the joint, and even snow driven by high winds is unable to enter.

c. The Observer's Chair.

This is not a chair in the common acceptation of the word, but is rather a movable platform three feet square, capable of carrying two or more persons round the observatory, and maintaining them in an invariable position with regard to the telescope eyepiece.

Its general arrangement is better comprehended from the sketch, Fig. 42, than from a labored description. Below, it runs on a pair of wheels *a* (one only is visible) 9 inches in diameter, whose axles point to the center of the circle upon which they run. They are prevented from shifting outward by a wooden railroad *b, b'*, and inward by the paling *I, I'*. Above, the chair moves on a pair of small rollers *c*, which press against a circular strip or track *d, d'*, nailed around the lower edge of the dome opening. Access to the platform is gained by the steps *e, e'*. Attached to the railing of this platform, and near it on the telescope, are two tables (not shown in the figure) for eyepieces, the sliding plateholder, etc.

§5. THE PHOTOGRAPHIC LABORATORY.

This section is divided into: a, Description of the Apartment; and b, Photographic Processes.

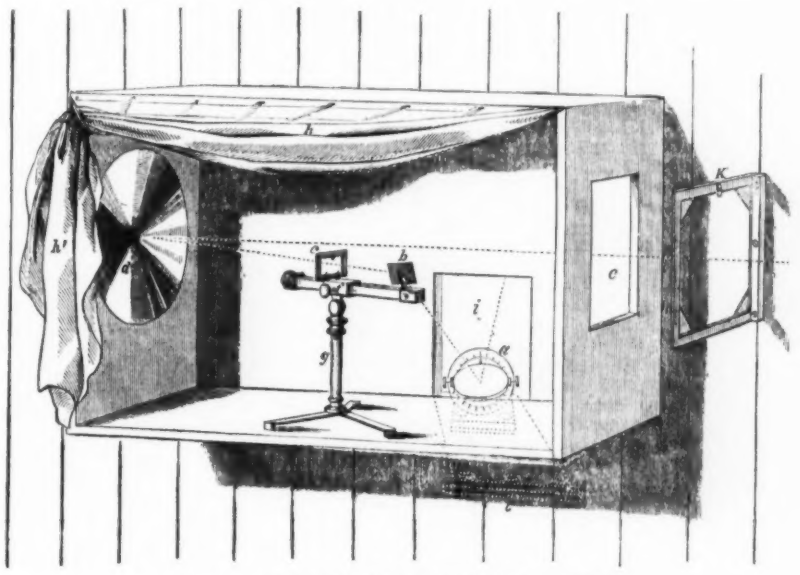


FIG. 46.—THE PHOTOGRAPHIC ENLARGER.

a. Description of the Apartment.

The room in which the photographical operations are carried on adjoins and connects with the observatory on the southeast, as is shown in Figs. 28 and 38. It is 9 by 10 feet inside, and is supplied with shelves and tables running nearly all the way round, which have upon them the principal chemical reagents. It is furnished, too, with an opening to admit, from a heliostat outside, a solar beam of any size, up to three inches in diameter.

The supply of water is derived from rain falling on the roof of the building, and running into a tank *i*,

FIG. 45.—DEVELOPING STAND.

Fig. 38, which will contain a ton weight. The roof exposes a surface of 532 square feet, and consequently a fall of rain equal to one inch in depth completely fills the tank. During the course of the year the fall at this place is about 32 inches, so that there is always an abundance. In order to keep the water free from contamination, the roof is painted with a ground mineral compound, which hardens to a stony consistence, and resists atmospheric influences well. The tank is lined with lead, but having been in use for many years for other purposes, is thoroughly coated inside with various salts of lead, sulphates, etc. In addition, the precaution is taken of emptying the tank by a large stopcock when a rainstorm is approaching, so that any accumulation of organic matter which can reduce nitrate of silver may be avoided. It has not been found feasible to use the well or spring water of the vicinity.

The tank is placed close under the eaves of the building, so as to gain as much head of water as is desirable. From near its bottom a pipe terminating in a stopcock *k*, Fig. 38, passes into the laboratory. In the northeast corner of the room, and under the tap, is a sink for refuse water and solutions, and over which the negatives are developed. It is on an average about twelve feet distant from the telescope. In another corner of the room is a stove, resembling in construction an open fireplace, but sufficient nevertheless to raise the temperature to 80 deg. F. or higher, if necessary. As a provision against heat in summer, the walls and roof are double, and a free space with numerous openings above is left for circulation of air, drawn from the foundations. The roof is of tinplate, fastened directly to the rafters, without sheathing, in order that heat may not accumulate to such an extent during the day as to constitute a source of disturbance when looking across it at night.

For containing negatives, which from being unvarnished require particular care, there is at one side of the room a case with twenty shallow drawers each to hold eighteen. They accumulate very rapidly, and were it not for frequent reselections the case would soon be filled. On some nights as many as seventeen negatives have been taken, most of which were worthy of preservation. Not less than 1,500 were made in 1862 and 1863.

b. Photographic Processes.

In photographic manipulations I have had the advantage of my father's long-continued experience. He worked for many years with bromide and chloride of silver in his photo-chemical researches (Journal of the Franklin Institute, 1837), and when Daguerre's beautiful process was published, was the first to apply it to the taking of portraits (Philosophical Magazine, June, 1840) in 1839—the most important of all the applications of the art. Subsequently he made photographs of the interference spectrum, and ascertained the existence of great groups of lines *M, N, O, P*, above *H*, and totally invisible to the naked eye (Philosophical Magazine, May, 1843). The importance of these results, and of the study of the structure of flames containing various elementary bodies, that he made at the same time, are only now exciting the interest they deserve.

In 1850, when his work on physiology was in preparation, and the numerous illustrations had to be produced, I learned microscopic photography, and soon after prepared the materials for the collodion process,

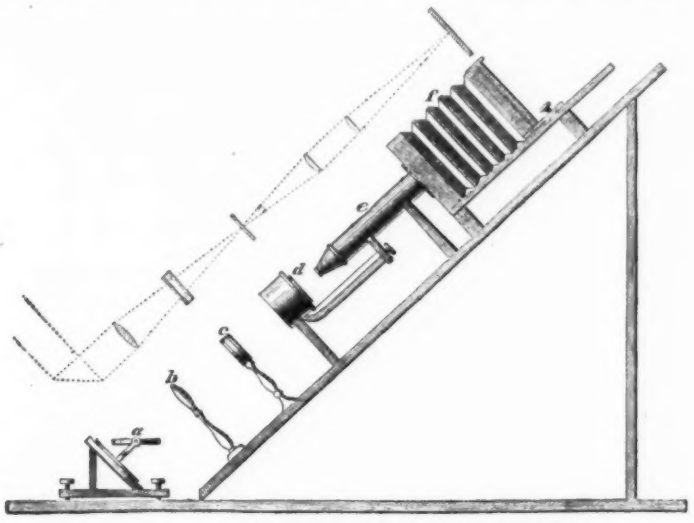


FIG. 47.—MICROSCOPE FOR PHOTOGRAPHY.

then recently invented by Scott Archer. We produced in 1856 many photographs under a power of 700 diameters, by the means described in the next section.

At first the usual processes for portrait photography were applied to taking the moon. But it was soon found necessary to abandon these and adopt others. When a collodion negative has to be enlarged—and this is always the case in lunar photography, where

the original picture is taken at the focus of an object glass or mirror—imperfections invisible to the naked eye assume an importance which causes the rejection of many otherwise excellent pictures. Some of these imperfections are pinholes, coarseness of granulation in the reduced silver, liability to stains and markings, spots produced by dust.

These were all avoided by washing off the free nitrate of silver from the sensitive plate, before exposing it to the light, and again submitting it to the action of water, and dipping it back into the nitrate of silver bath before developing. The quantity of nitrate of silver necessary to development when pyrogallic acid is used is, however, better procured by mixing a small quantity of a standard solution of that salt with the acid.

The operation of taking a lunar negative is as follows. The glass plates 2¾ x 3¼ inches are kept in nitric acid and water until wanted. They are then washed under a tap, being well rubbed with the fingers, which have of course been properly cleaned. They are wiped with a towel kept for the purpose. Next a few drops of iodized collodion are poured on each side, and spread with a piece of cotton flannel. They are then polished with a large piece of this flannel, and deposited in a close dry-plate box. This system of cleaning with collodion was suggested by Major Russel, to whose skillful experiments photography is indebted for the tannin process. It certainly is most effective, the drying pyroxyline removing every injurious impurity. There is never any trouble from dirty plates.

The stock of plates for the night's work, a dozen or so, being thus prepared, one of them is taken, and by movement through the air is freed from fibers of cotton. It is then coated with filtered collodion, being held near the damp sink. The coated plate, when sufficiently dry, is immersed in a forty-grain nitrate of silver bath, acidified with nitric acid until it reddens litmus paper. The exact amount of acid in the bath makes in this "washed plate process" but little difference. When the iodide and bromide of silver are thoroughly formed, the plate is removed, drained for a moment, and then held under the tap till all greasiness, as it is called, disappears. Both front and back receive the current in turn.

It is then exposed, being carried on a little wooden stand, Fig. 43, covered with filtering paper to the telescope, and deposited on the sliding plateholder which has been set to the direction and rate of the moon, while the plate was in the bath. The time of exposure is ascertained by counting the beats of a half-second pendulum.

The method by which exposure without causing tremor is accomplished, is as follows: A yellow glass slides through the eyepiece-holder, Fig. 33, just in front of the sensitive plate, and is put in before the plate. The yellow-colored moon is centered on the collodion film, and the clepsydra and slide are set in motion, the mass of the telescope being at rest. A pasteboard screen is put in front of the telescope, and the yellow glass taken out. After twenty seconds, the instrument remaining still untouched and motionless, the screen is withdrawn, and as many seconds allowed to elapse as desirable. The screen is then replaced and the plate taken back to the photographic room.

After being again put under the tap to remove any dust or impurity, it is dipped into the nitrate bath for a few seconds. Two drachms of a solution of protosulphate of iron 20 grains, acetic acid 1 drachm, and water 1 ounce, is poured on it. As soon as the image is fairly visible this is washed off, and the development continued if necessary with a weak solution of pyrogallic acid and citro-nitrate of silver—pyrogallic and citric acids each 1-5 grain, nitrate of silver 1-10 grain, water 1 drachm. In order to measure these small quantities standard solutions of the substances are made, so that two drops of each contain the desired amount. They are kept in bottles, through the corks of which pipettes descend to just below the level of the liquid. This avoids all necessity of filtering, and yet no blemishes are produced by particles of floating matter.

During the earlier part of the development, when the protosulphate of iron is on the film, an accurate judgment can be formed as to the proper length of time for the exposure in the telescope. If the image appears in ten seconds, it will acquire an appropriate density for enlargement in forty-five seconds, and will have the minimum of what is called fogging and the smallest granulations. If it takes longer to make its first appearance the exposure must be lengthened, and *vice versa*.

The latter part of the development, when re-development is practised, is purposely made slow, so that the gradation of tones may be varied by changing the proportion of the ingredients. As it would be tiresome and uncleanly to hold the plates in the hand, a simple stand is used to keep them level. It consists of a piece of thin wood *a*, Fig. 45, with an ordinary wood screw, as at *b*, going through each corner. Four wooden pegs, as at *c*, furnish a support for the plate *d*. By the aid of this contrivance and the washing system, I seldom get my fingers marked, and what is much more important, rarely stain a picture.

When the degree of intensity most suitable for subsequent enlargement is reached, that is, when the picture is like an overdone positive, the plate is again flooded with water, treated with cyanide of potassium of hyposulphate of soda, once more washed, and set upon an angle on filtering paper to dry. It is next morning labeled, and put away unvarnished in the case.

To the remark that this process implies a great deal of extra trouble, it can only be replied that more negatives can be taken on each night that can be kept, and that, even were it not so, one good picture is worth more than any number of bad ones.

Although the above is the method at present adopted, and by which excellent results have been obtained, it may at any moment give place to some other, and is indeed being continually modified. The defects it presents are two—first, the time of exposure is too long, and second, there is a certain amount of lateral diffusion in the thickness of the film, and in consequence a degree of sharpness inferior to that of the image produced by the parabolic mirror. The shortest time in which the moon has been taken in this observatory has been one-third of a second, on the twenty-first day, but on that occasion the sky was singularly clear, and the intrinsic splendor of the light great. The full moon under the same circumstances would have required a much shorter exposure. A person, however, who has put his eye at the focus of such a silvered mirror will not be surprised at the shortness of the time needed for impressing the bromo-iodide film; the brilliancy is so great that it impairs vision, and for a long time the exposed eye fails to distinguish any moderately illuminated object. The light from 188 square inches of an almost total reflecting surface is condensed upon two square inches of sensitive plate.

Occasionally a condition of the sky, the reverse of that mentioned above, occurs. The moon assumes a pale yellow color, and will continue to be of that non-actinic tint for a month or six weeks. This phenomenon is not confined to special localities, but may extend over great tracts of country. In August, 1862, when our regiment was encamped in Virginia, at Harper's Ferry, the atmosphere was in this condition there, and was also similarly affected at the observatory, more than 200 miles distant. As to the cause, it was not forest or prairie fires, for none of them of sufficient magnitude and duration occurred, but was probably dust in a state of minute division. No continued rain fell for several weeks, and the clay of the Virginia roads was turned into a fine powder for a depth of many inches. The Upper Potomac River was so low that it could be crossed dry-shod. On a subsequent occasion when the same state of things occurred again, I exposed a series of plates (whose sensitiveness was not less than usual, as was proved by a standard artificial flame) to the image of the full moon in the 15½-inch reflector for twenty seconds, and yet obtained only a moderately intense picture. This was forty times as long as common.

Upon all photographic pictures of celestial objects the influence of the atmosphere is seen, being sometimes greater and sometimes less. To obtain the best impressions, just as steady a night is necessary as for critical observations. If the image of Jupiter is allowed to pass across a sensitive plate, a streak almost as wide as the planet is left. It is easily seen not to be continuous, as it would have been were there no atmospheric disturbances, but composed of a set of partially isolated images. Besides this planet, I have also taken impressions of Venus, Mars, double stars, etc.

An attempt has been made to overcome lateral diffusion in the thickness of the film by the use of dry collodion plates, more particularly those of Major Russel and Dr. Hill Norris. These present, it is true, a fine and very thin film during exposure, but while developing are so changed by wetting in their mechanical condition that no advantage has resulted. It was while trying them that I ascertained the great control that hot water exercises over the rapidity of development, and time of exposure, owing partly no doubt to increase of permeability in the collodion film, but also partly to the fact that chemical decompositions go on more rapidly at higher temperatures. I have attempted in vain to develop a tannin plate when it and the solutions used were at 32 deg. F., and this though it had had a hundred times the exposure to light that was demanded when the plate was kept at 140 deg. F. by warm water.

Protochloride of palladium, which I introduced in 1859, is frequently employed when it is desired to increase the intensity of a negative without altering its thickness. This substance will augment the opacity sixteen times, without any tendency to injure the image or produce markings. It is only at present kept out of general use by the scarcity of the metal.

§6. THE PHOTOGRAPHIC ENLARGER.

Two distinct arrangements are used for enlarging, a, for Low Powers, varying from 1 to 25; and b, for High Powers from 50 to 700 diameters.

a. Low Powers.

The essential feature in this contrivance is an entire novelty in photographic enlargement, and it is so superior to solar cameras, as they are called, that they are never used in the observatory now. It consists in employing instead of an achromatic combination of lenses, a *mirror* of appropriate curvature to magnify the original negatives or objects. The advantages are easily enumerated, perfect coincidence of visual and chemical foci, flat field, absolute sharpness of definition. If the negative is a fine one, the enlarged proofs will be as good as possible.

The mirror is of 9 inches aperture, and 11½ inches focal length. It was polished on my machine to an elliptical figure of 8 feet distance between the conjugate foci, and was intended to magnify seven times. At first the whole mirror was allowed to officiate, the object being illuminated by diffused daylight. But it was soon apparent that although a minute object placed in one focus was perfectly reproduced at the other, seven times as large, yet a large one was not equally well defined in all its parts.

I determined then to produce the enlarged image by passing a solar beam 1½ inch in diameter through the original lunar negative—placed in the focus nearest to the mirror—and allowing it to fall on a portion of the concave mirror, 1½ inch in diameter, at one side of the vortex. Being reflected, it returns past the negative, and goes to form the magnified image at the other focus of the ellipse.

In Fig. 46, *a* is the heliostat on a stone shelf outside; *b* a silvered glass mirror, to direct the parallel rays through *c*, the negative; *d* is the elliptical mirror; *e* an aperture to be partly closed by diaphragms; *f* a rackwork movemen: carried by the tripod *g*; the curtain *h h'* shuts out stray light from the interior of the observatory. The aperture *i* is also diaphragmed, but is shown open to indicate the position of the heliostat, the shelf of which joins the outside of the building at *l*. The dotted line points out the course of the light, which coming from the sun falls on the heliostat mirror *a*, then on *b*, through *c* to *d*, and thence returning through *c* to the sensitive plate in the plate holder *k*.

The distance of this last can be made to vary, being either two feet or twenty-eight feet from *d*. In the latter case a magnifying power of about 25 results, the moon being made three feet in diameter. The sensitive plate is carried by a frame, which screws to the side wall of the building, and can be easily changed in position. The focusing is accomplished by the rack *f*. Where so small a part (1½ inch) of the surface of the mirror is used, a rigid adherence then to the true foci of this ellipse is not demanded, the mirror seeming to perform equally well whether magnifying 7 or 25 times. Theoretically it would seem to be limited to the former power.

If instead of placing a lunar photograph, which in the nature of the case is never absolutely sharp, at *c*, some natural object, as for instance a section of bone, is attached to the frame moved by *f*, then under a power of 25 times it is as well defined as in any microscope, while at the same time the amount of its surface seen at once is much larger than in such instruments, and the field is flat. If the intention were, however, to make microscopic photographs, a mirror of much shorter focal length would be desirable, one approaching more to those of Amici's microscopes.

By the aid of a concave mirror used thus obliquely, or eccentrically, all the difficulties in the way of enlarging disappear, and pictures of the greatest size can be produced in perfection. I should long ago have made lunar photographs of more than 3 feet in diameter, except for the difficulties of manipulating such large surfaces.

In order to secure a constant beam of sunlight a heliostat is placed outside the observatory, at its southeast corner, *f*, Fig. 38. This beam, which can be sent for an entire day in the direction of the earth's axis, is intercepted as shown at *b*, Fig. 46, and thus if needed an exposure of many hours could be given. The interior of the observatory and photographic room being only illuminated by faint yellow rays, no camera box is required to cut off stray light. The eye is by these means kept in a most sensitive condition, and the focusing can be effected with the critical accuracy that the optical arrangement allows, no correction for chromatic aberration being demanded.

I have made all parts of this apparatus so that they can be easily separated or changed. The flat mirrors are of silvered glass, and are used with the silvered side toward the light, to avoid the double image produced when reflection from both sides of a parallel plate of glass is permitted. The large concave mirror happens to be of speculum metal, but it can be repolished if necessary by means of a 4-inch polisher, passed in succession over every chord of the face. A yellow film of tarnish easily accumulates on metal specula if they are not carefully kept, and decreases their photographic power seriously.

Of the Making of Reverses.—In addition to the use of the enlarger for magnifying, it is found to have important advantages in copying by contact. The picture of the image of the moon produced in the telescope is negative, that is, the lights and shades are reversed. In enlarging such a negative reversal again takes place, and a positive results. This positive cannot, however, be used to make prints on paper, because in that operation reversing of light and shade once more occurs. It is necessary then at some stage to introduce still another reversal. This may be accomplished either by printing from the original negative a positive, which may be enlarged, or else printing from the enlarged positive a negative to make the paper proofs from. In either case a collodion film, properly sensitized, is placed behind the positive or negative, and the two exposed to light.

If diffused light or lamplight is used, the two plates must be as closely in contact as possible, or the sharpness of the resulting proof is greatly less than the original. This is because the light finds its way through in many various directions. If the two plates, however, are placed in the cone of sunlight coming from the enlarger, and at a distance of fifteen or twenty feet from it, the light passes in straight lines and only in one direction through the front picture to the sensitive plate behind. I have not been able to see under these circumstances any perceptible diminution in sharpness, though the plates had been 1-16 of an inch apart. It is perfectly feasible to use wet collodion instead of dry plates, no risk of scratching by contact is incurred, and the whole operation is easily and quickly performed. The time of exposure,

5 seconds, is of convenient length, but may be increased by putting a less reflecting surface or an unsilvered glass mirror in the heliostat. A diaphragm with an aperture of half an inch is placed at *c*, Fig. 46, to shut out needless light, and avoid injuring the sharpness of the reverse by diffusion through the room. In enlarging other diaphragms are also for the same reason put in the place of this one. For a half moon, for instance, a yellow paper with a half circular aperture, whose size may be found by trial in a few minutes, is pinned against *c*.

The enlarged pictures obtained by this apparatus are much better than can be obtained by any other method known at present. The effect, for instance, of a portrait, made life-size, is very striking. Some astronomers have supposed that advantages would arise from taking original lunar negatives of larger size in the telescope, that is, from enlarging the image two or three times by a suitable eye-piece or concave achromatic, before it reached the sensitive plate. But apart from the fact that a reflector would then have all the disadvantages of an achromatic, the atmospheric difficulties, which in reality constitute the great obstacle to success, would not be diminished by such means. The apparent advantage, that of not magnifying defects in the collodion, is not of much moment, for when development of the photographs is properly conducted, and thorough cleanliness practised, imperfections are not produced, and the size of the silver granules is not objectionable.

b. High Powers.

Although negatives of astronomical objects have not as yet been made which could stand the high powers of the arrangement about to be described, yet they bear the lower powers well, and give promise of improvement in the future.

Photography of microscopic objects as usually described, consists in passing a beam of light through the transparent object into the compound body of the microscope, and receiving it on its exit from the eye-piece upon a ground glass or sensitive plate. The difficulty which besets the instrument generally, and interferes with the production of fine results, arises from the uncertainty of ascertaining the focus or place for the sensitive plate. For if the collodion film be put where the image on ground glass seems best defined, the resulting photograph will not be sharp, because the actinic rays do not form their image there, but either farther from or nearer to the lenses, depending on the amount of the chromatic correction given by the optician. Practically by repeated trials and variation of the place of the sensitive compound, an approximation to the focus of the rays of maximum photographic intensity is reached.

During my father's experiments on light, and more particularly when engaged in the invention of portrait photography, he found that the ammonio-sulphate of copper, a deep blue liquid, will separate the more refrangible rays of light, the rays concerned in photography, from the rest. If a beam of sunlight be passed through such a solution, inclosed between parallel plates of glass, and then condensed upon an object on the stage of a microscope, a blue colored image will be formed on the ground glass, above the eyepiece. If the place of best definition be carefully ascertained, and a sensitive plate put in the stead of the ground glass, a sharp photograph will always result.

Besides, there is no danger of burning up the object, as there would be if the unabsorbed sunlight were condensed on it, and hence a much larger beam of light and much higher powers can be used. The best results are attained when an image of the sun produced by a short-focused lens is made to fall upon and coincide with the transparent object. In 1856 we obtained photographs of frog's blood disks, *navicula angulata*, and several other similar objects under a power of 700 diameters, excellently defined. Since then several hundreds of microscopic pictures have been taken.

In the figure, *a* is the heliostat, *b* a lens of three inches aperture, *c* the glass cell for the ammonio-sulphate of copper, *d* the object on the stage of the microscope *e*, *f* the camera for the ground glass or sensitive plate. Above the figure the course of the rays is shown by dotted lines.

In concluding this account of a silvered glass telescope I may answer an inquiry which doubtless will be made by many readers, whether this kind of reflector can ever rival in size and efficiency such great metallic specula as those of Sir William Herschel, the Earl of Rosse, and Mr. Lassell? My experience in the matter, strengthened by the recent successful attempt of M. Foucault to figure such a surface more than thirty inches in diameter, assures me that not only can the four and six-foot telescopes of those astronomers be equaled, but even excelled. It is merely an affair of expense and patience. I hope that the minute details I have given in this paper may lead some one to make the effort.

The average production of wheat in this country is little more than 12 bushels per acre; for corn, the average production is 25½ bushels per acre; for oats and barley, the average production is 28 and 26 bushels per acre, respectively. During the past thirty years there has been a constant variation of these averages for different parts of the country. In the great grain-producing areas of the West the average has been decreasing. In certain sections of the East, on the other hand, the average has been growing higher

SCIENCE NOTES.

Moses himself was a sanitarian of no mean accomplishments, and many of the principles established by him in sanitary science might well be exploited in modern times. The type of camp which he established for the detention of unfortunate lepers, well modified to suit modern principles, would serve for the check and practical elimination of consumption.

Health comes largely from good food and good hygiene, but one of the necessities to health is good mastication. Teeth are useful for other purposes than merely to improve looks, but even if they were only for this purpose they would be worth saving. As in surgery, dentistry is conservative, and he serves man best who enables him to keep the teeth which nature has provided. The physician of the future as well as the dentist must be the arbiter of good health, and good health comes largely from good food and good hygiene; good food well masticated and good hygiene well applied. The farmer furnishes the food, the dentist secures its mastication, and the physician formulates the laws of health and helps to restore to the normal any diseased organ of the body. The first thing, therefore, which the physician of the future must see to is the food supply, not that he is expected to till the soil and produce its fruits, but that he is to help in the great work of restoring foods to their normal state.

The farmer always will be relatively conservative. His business is rooted in the earth. In a thoroughly well-developed agriculture, the farmer does not move his business rapidly from place to place. He remains, while others move on. Therefore, it is especially necessary that we extend to him all the essential benefits of our civilization. He has the rural free delivery of mails—although this was thought to be impossible a few years ago. Shall he not have a parcels post? Each year the good roads movement, originating at the cities, is extending itself farther into the real country. Trolley lines are extending countryward; soon they will come actually to serve the farmer's needs. The telephone, as a separate rural enterprise, is extending itself. Extensional educational enterprises are reaching farther and farther into the open farming districts. Co-operation and organization movements are at the same time extending and concreting themselves.

The castor-bean supply of the United States is derived almost entirely from two widely separate sources: The first, a few counties in Oklahoma, eastern Kansas, western Missouri, and southwestern Illinois, where for many years has been produced practically the entire domestic crop; the second, British India, a country which has long had almost a monopoly of the commercial castor-bean production of the world. The domestic crop, once sufficient to supply the entire demand—that is, of the eastern as well as the western mills—has of late years greatly declined. And at present a striking feature of this industry is that, although the castor oil used in the United States is manufactured almost wholly in domestic mills, the bulk of the beans from which it is expressed is imported from the opposite side of the earth. Although statistics upon domestic production are deficient, enough is known to warrant the statement that probably three-fourths, possibly four-fifths, of the castor oil manufactured in the United States is now made from imported beans.

Recent results tend to emphasize the importance of considering to a greater degree the physical conditions of the soil. Some have even gone so far as to claim that practically all soils contain a sufficient quantity of plant food; and that the all-important question is the regulation of the water supply in accordance with the quality of the particular soil. This latter, however, is an error into which few physiologists have fallen. Nevertheless, precise studies upon the relation of plants to the physical characters of soils afford problems which should receive the best attention. Many of the problems are not new, and in a qualitative way, at least, the problem of the relationship of the conservation of moisture and the tilth of the soil to productiveness has been duly appreciated by the best agronomists. We must notice with regret, therefore, that botanists have not always appreciated the importance of such work. Either directly or indirectly the water factor is a chief one in regulating the activities of the living plant and must be considered from every possible point of view.

As is well known, an increase of the carbon percentage in steel implies a corresponding increase of the coercive force and also of the hysteresis energy loss. These facts have been found to be very distinctly borne out by the figures obtained for the sheet metal. The increase of the coercive force and the Steinmetz hysteresis coefficient have been found to follow a straight line within the range of a carbon percentage of 0.5 per cent. Thus it is obvious that a small amount of carbon is favorable in sheets used in armature cores and transformers. As regards the cast steel, however, it seems as if there ought not to be any inconvenience whatever involved in the increase of the carbon percentage, so far as is shown by the present researches. With the very highest percentage met with in the cast steel employed (carbon = about 0.30 per cent) the values of the maximum induction and of the permeability at the induction normal usual in field poles, cannot but be considered as quite satisfactory; while on the other hand, as mentioned above, the hysteresis properties of the pole material are comparatively unimportant. A high percentage of carbon also produces an increase in the electrical resistance, an effect which must be considered advantageous.

ENGINEERING NOTES.

Girder-work over sea-water, as in piers, seems to rust at a sensibly greater rate than inland work under average conditions; but it is hardly practicable to make any strict comparison, as in either case the rate of oxidation is so much affected—even controlled—by the care bestowed upon the structures. This general conclusion is based upon the results of examination of wrought-iron girder work over sea-water of ages varying from fourteen to forty-four years. It should be remarked, however, that in one case steel girders but five years old, and which were frequently wetted with sea-spray, were found to be wasting rather badly—the paint refusing to keep upon the surface.

The underfeed stokers operate on an entirely different principle, the coal being fed in underneath the grate and forced up through a rectangular opening in the center. A forced blast is used and the air for combustion is blown up through the coal, the tuyeres being on either side of the rectangular opening just mentioned. By this arrangement the fresh coal is always underneath and the distilled gases are obliged to pass through an incandescent mass of fuel in company with the air. With a proper pressure of blast perfect combustion is thus almost unavoidable. The ash and clinker are now at the top of the fuel, which forms a gradually-rising mound in the center and pushes the clinker over to either side, whence it is removed by hooks through doors at the front. The heat generated is such that the ash generally melts and forms a sheet of clinker which can be easily removed without disturbing the fire.

Steam is a fluid much less complex in nature than explosive mixtures. The action of steam is governed by precise laws which pertain only to the sphere of physics, while the production of combustible gases and their mode of evolution under the form of explosive mixtures in engines, are as much within the domain of chemistry as of physics and mechanics. Although the generic theory of gas-engines has rested up to the present on a series of hypotheses which have not yet received experimental confirmation, these engines have gained ground in application to various industries with exceptional rapidity compared with any other kind of motive power. The invention of gas producers and the improvements made in the last few years, and especially in those working with the direct suction of the engines, are manifestly most important factors in this success.

Algebraic symbols were first used by Vieta, 1590; logarithms by Napier, 1614, and decimal fractions, 1617. A precise measure of length was first suggested by Huygens, the Dutch astronomer, 1658, upon the basis of the length of a pendulum vibrating seconds of mean time. Bacon's Inductive Philosophy appeared in 1616; Harvey discovered the circulation of the blood in 1618; Snellings proved the law of refraction, 1624; Torricelli demonstrated the pressure of the atmosphere, 1645; and Otto Guericke invented the air pump, 1650. The quadrant for measuring angles was invented in 1600; the pendulum for clocks at about the same time; the telescope, 1610; microscopes in Italy, 1619; and Holland, 1621; the thermometer by Drebbel and Sarpi, 1609; the barometer, 1626; the micrometer, 1622-40; and the camera obscura in 1650. In 1635 Richelieu founded the French Academy, and opened that path of distinction to science which hitherto had been reserved only for valor.—Del Mar's "History of Monetary Systems."

All the methods in use in conducting laboratory instruction may be placed between two limits. At the lower limit there is provided in connection with each piece of apparatus a complete description of one determination that can be made by the apparatus, including instructions for manipulation, a list of data to be observed and the computation of results therefrom, all illustrated by an example. There is practically no thinking required, and about all the student acquires is skill in manipulation, aside from a few facts on the results. The method which may be placed at the upper limit is pure research, in which the student is given a problem to solve experimentally and receives no further help. The method of attack, the data, the selection, use and manipulation of apparatus and the computations involved, are all left to be determined by the student, without assistance but without restriction. An illustration of such a problem is one given by the world to all engineers for solution: "Is the gas turbine a possibility, economically and mechanically?" Between these two limits the methods in use leave to the student some unsolved elements, and require more or less thinking, and as a result will require more or less time on his part.

Instruction in engineering by the experimental method through the medium of laboratories is so generally accepted as necessary to the training of professional engineers that at this time it needs no defense. The details of execution of such laboratory instruction and the exact results to be attained which should control the executive element are, however, not the same in the different technical schools in this country. This fact was brought out most forcibly by the numerous visiting engineers and investigating technical committees from abroad attending the St. Louis Exposition. Conversation with these gentlemen and later statements in their printed reports and papers show that while deploring the lack of uniformity of technical instruction in general in their own countries and admitting, in most cases, the superiority of the American system, they question the advantages to be derived from our admittedly magnificent laboratory equip-

ments, basing the judgment, of course, on their observations. The unlike methods of handling laboratory apparatus in use in our different institutions, and the variety of professed aims for that part of the instruction dependent on this apparatus, which makes the European doubt that advantages are derived proportionate to the expenditure involved, is at least worth investigation.

TRADE NOTES AND RECIPES.

A New Hardening Agent for Steel.—Dr. P. Galopin, of Geneva, uses for the hardening of steel, glycerine whose action may be further assisted by addition of dissolved chlorides of the alkalies, especially earthy alkalies. Glycerine has the advantage that in consequence of its unlimited solubility in water its quantitative proportion may be varied exceedingly and with it the desired degrees of action. A steel-hardening solution of this kind consists, for instance, of glycerine 5 kilos, cooking salt 500 grammes, sal-ammoniac 100 grammes, concentrated hydrochloric acid 50 grammes, and water 10 kilos. Into this liquid the steel, heated, for example, to a cherry red, is dipped. A reheating of the steel is not necessary.—Allgemeine Chemiker Zeitung.

Waterproofing of Wood.—According to Ch. Girard, director of the Municipal Laboratory of Chemistry in Paris, the most suitable means of fireproofing wood consists in impregnating it with a solution of the following composition:

Ammonium phosphate	100 kilos
Boracic acid	10 kilos
Water	1,000 liters

Not quite such good results are obtained by impregnation with the following solution:

Ammonium sulphate	135 kilos
Borax	15 kilos
Boracic acid	5 kilos
Water	1,000 liters

For the production of fireproof coating on wood a mixture of the following composition is applied in several layers, one on top of the other:

Water glass	1,000
Chalk	500
Glue	1,000

Or an application is made of the following solutions or mixtures in the rotation as specified:

1.	Ammonium sulphate	20 grammes
	Water	1 liter
2.	Soluble soda glass	50 grammes
	Water	1 liter
3.	Sodium silicate (solid)	350 grammes
	Powdered asbestos	350 grammes
	Water	1 liter
4.	Powdered asbestos	35 grammes
	Water	100 c.cm.
	Borax	20 grammes
	Gum-lac	10 to 15 grammes

—Neueste Erfindungen und Erfahrungen.

Soft-Solder Alloys.—Casting alloys for the manufacture of tin figures, buttons, small candlesticks, ornamental disks, etc.:

Tin	4
Lead	3

Readily fusible, rather soft, yielding very sharp impressions.

Tin	8.0
Lead	6.0
Antimony	0.5

Rather easily fusible, but somewhat brittle and harder than the foregoing alloy.

Sheet Metal Alloy.

Tin	35.0
Lead	25.0
Copper	2.5
Zinc	0.5

This alloy, of a handsome white color, can be readily rolled out into very thin sheets or foil and is used for lining tea boxes, for making receptacles to hold smoking tobacco, wrapping up chocolate, etc. The copper and zinc are made use of in the shape of fine chips and the alloy cast at once in thin plates, which are then stretched between rollers into paper-like sheets.

Brilliant Alloy.

Tin	29
Lead	19

This alloy excels in exceedingly high luster of great permanency and may therefore be employed for the imitation of diamonds and other precious stones for stage purposes.

As a rule an alloy consisting of 2 parts tin and 1 part lead is prepared to which tin is added until a drop let fall upon a smooth plate of iron forms a mirror.

The "diamonds" are produced by dipping a piece of glass cut in the shape of a precious stone, quickly into the molten alloy, withdrawing it again and allowing to cool. The small amount of alloy which clings to the stone, solidifies rapidly and drops off.

From the outside these "diamonds" appear rough and exhibit a gray color but the smooth inside reflects the light very prettily, giving the stone in artificial light the appearance of a real diamond. If the reflecting surfaces are coated with red, blue or green aniline varnish the effect of these colors will be perceptible along with the mirror-like brilliancy.

In place of the easily cracking glass gem, tin diamonds can be produced by means of suitably-cut pieces of well-polished steel or bronze.—Neueste Erfindungen und Erfahrungen.

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TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—Experiments with the Langley Aerodrome.—By S. P. LANGLEY.—5 illustrations 24766
The Latest Performances of Typical French, English and American Airships 24771

II. AUTOMOBILES.—Forty-Horse-power Gasoline Tractor for the British War Office.—1 illustration 24773

III. ELECTRICITY.—Electric Ignition Systems.—By E. W. ROBERTS.—6 illustrations 24769
Electric Power from Blast Furnaces.—By F. EYERMANN 24774
Electrically-heated Carbon Tube Furnaces.—3 illustrations 24779

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